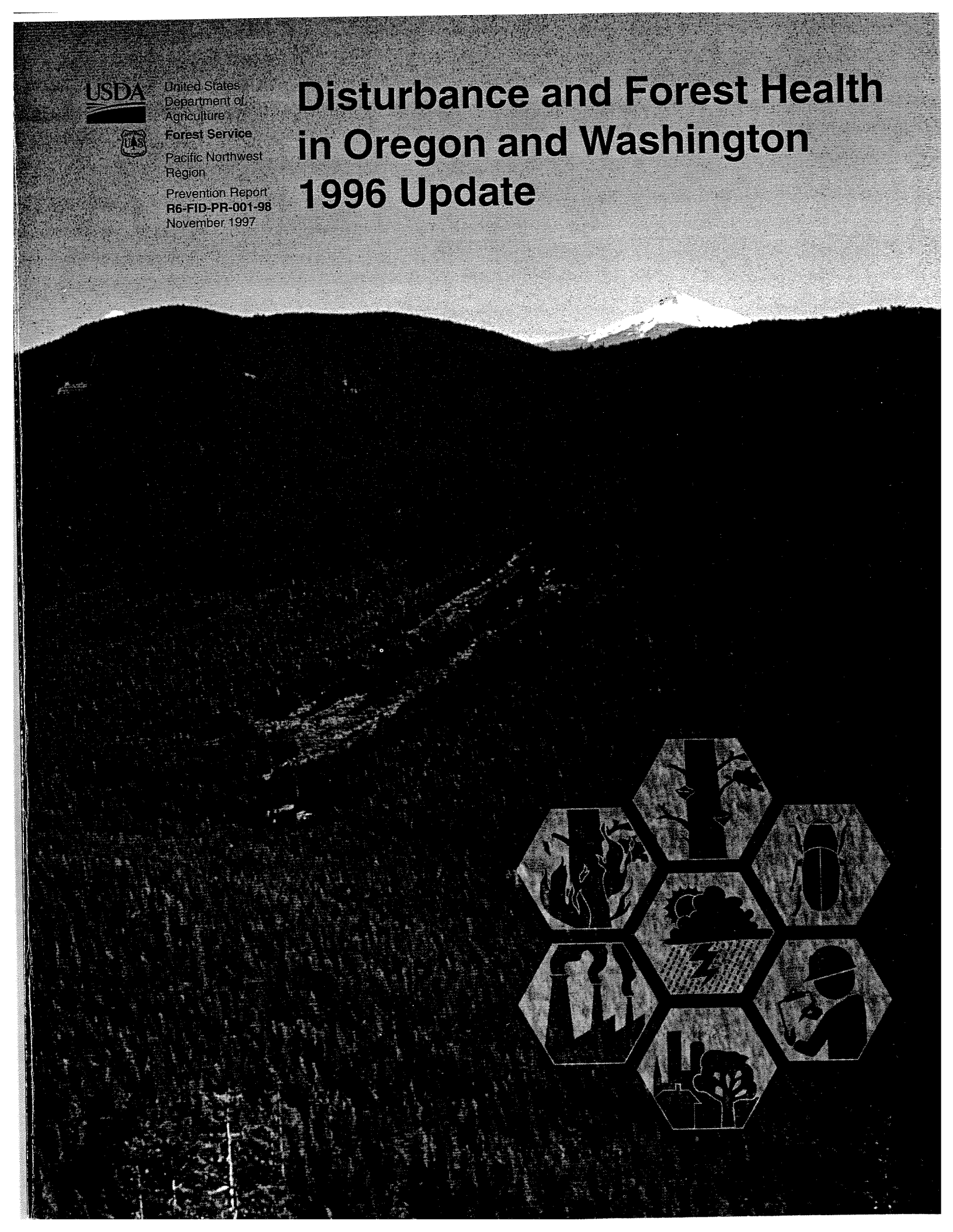
USDA United States Department of Agriculture
Forest Service
Pacific Northwest Region
Prevention Report
R6-FID-PR-001-98
November 1997

Disturbance and Forest Health in Oregon and Washington 1996 Update



Disturbance and Forest Health in Oregon and Washington 1996 Update

Prepared by: Sally Campbell, Virginia Hokkanen, Julie Johnson, and Keith Sprengel

USDA Forest Service
Pacific Northwest Region
Portland, Oregon
Prevention Report R6-FID-PR-001-98
November 1997

TABLE OF CONTENTS

LIST OF GRAPHS, TABLES, AND MAPS

Appendices:

REGIONAL SUMMARY

In 1996, insect-caused mortality and defoliation decreased for most locations and for most insects. Some of this decrease, particularly for bark beetles, was due to increasing precipitation in 1995 which lessened moisture stress and susceptibility of trees to beetle attack. High stand density in many areas, however, continues to predispose stands to bark beetle infestations.

Notable exceptions include increases in true fir mortality from fir engraver in central Oregon and increases in spruce mortality from spruce beetle and Ips in northeast Washington.

Swiss needle cast, a foliage disease of Douglas-fir, has been increasing along the coast of both states in recent years. It was surveyed in Oregon by a special spring aerial survey for the first time in 1996; about 130,000 acres of discolored Douglas-fir was mapped. Higher than normal precipitation, especially in the spring, resulted in increases in a number of foliage diseases throughout northwest forests in 1996.

Data from the Current Vegetation Survey on national forests has provided improved information on incidence of dwarf mistletoe and root disease: approximately 41 percent of all plots in Oregon and Washington contain trees with dwarf mistletoe infections and about 22 percent of all plots have trees with root disease.

Damage caused by bears increased in the western portion of both states in 1996.

Exotic pests continue to have serious impacts on forests in Oregon and Washington, especially two long-established diseases, Port-Orford-cedar root disease and white pine blister rust, and one long-established insect, the balsam woolly adelgid. Although aerial survey fails to detect a large proportion of the mortality and damage caused by these exotics, ground observations confirm continuing losses. Similarly, noxious weeds are a mounting problem in Oregon and Washington forests and rangelands. Where trend data exist, they show dramatic spread of noxious weeds in the northwest.

Air pollution monitoring in 1996 showed fewer pollution-sensitive lichens in the Columbia River gorge and in the Portland metropolitan area, indicating poorer air quality in those areas. Visibility and air quality have improved in the vicinity of the Centralia Coal Fired Power Plant due to an agreement to reduce plant emissions. Alpine lakes continue to be monitored for baseline chemical condition, and acidity changes due to acid deposition.

Approximately 636,000 acres of state and federal forests burned in 1996. It was one of the most severe fire years, particularly in eastern Oregon, in recent history. Weather played a critical role, with a wetter than usual spring allowing for more growth of fine fuels, above normal temperatures and rapid fuel drying in mid-summer, and intense lightning activity. Washington and western Oregon had significantly fewer fires than eastern Oregon due, in part, to wetter weather conditions.

Extreme winter weather, from November 1995 to February 1996, resulted in forest damage in many areas including tree breakage and windthrow from heavy snowpack, ice, and wind; and landslides and flood damage to roads, trails, and streams. Precipitation for the 1996 calendar year was above average throughout both states.

INTRODUCTION

Disturbance. Disturbances in forests are caused by both living and nonliving entities, such as insects, diseases, large animals, fire, weather, and air pollution. Damage to trees from disturbance agents can occur in small areas or over large landscapes. Often tree damage or mortality is caused by several agents, such as drought and bark beetles, working together or in sequence. Other factors too, such as high stand density, can affect the amount of damage from disturbance agents.

The purpose of this report is to provide disturbance monitoring data for 1996 for Oregon and Washington. This is an update to the earlier report, "Disturbance and Forest Health in Oregon and Washington," which reported on 1995 conditions.

Forest Health Monitoring. Forest Health Monitoring (FHM) is a national program, with both state and federal cooperators. Insect and disease monitoring is part of FHM. In 1996, the primary insect and disease monitoring activity was the annual cooperative (Forest Service, states of Oregon and Washington) aerial survey, covering all forested lands in Oregon and Washington. Other insect and disease surveys or observations were carried out as needed in localized areas by either state or Forest Service insect and disease staff. Insect and disease data from Current Vegetation Survey (CVS) plots on national forests has also been summarized for this report.

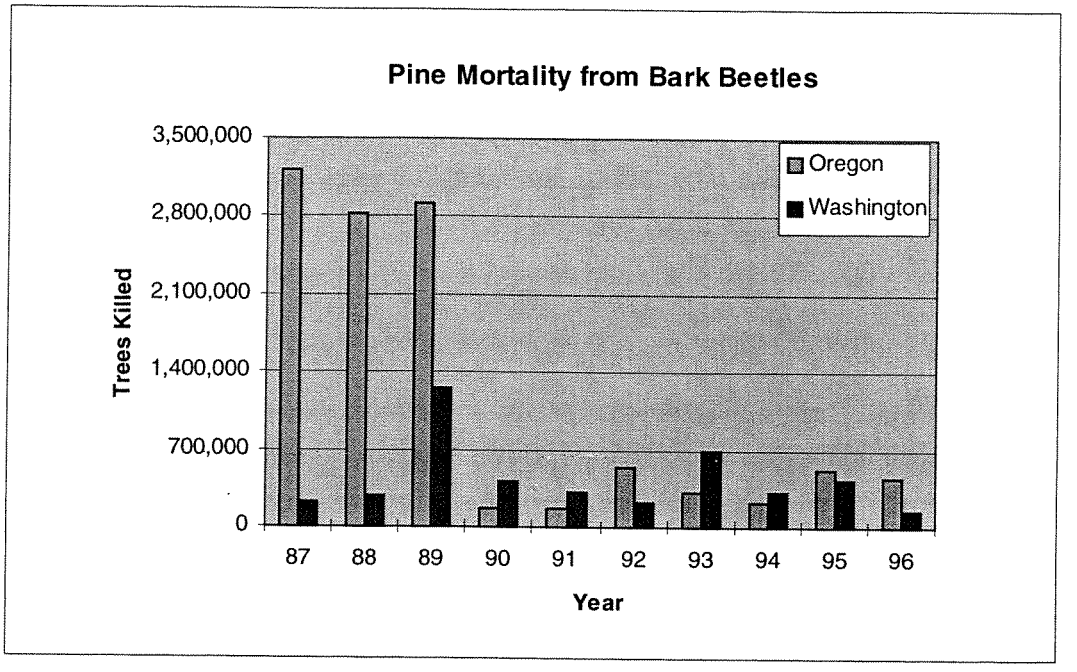
Other sources of disturbance monitoring information for 1996, such as noxious weed, air pollution, fire, and weather data, are also considered part of forest health monitoring and have been used in this report to explain changes in the condition of Oregon and Washington forests. This information was provided by both Forest Service and state specialists.

Preparations were made in 1996 for another part of the national Forest Health Monitoring program – the FHM plot network – that was implemented in 1997 in Oregon and Washington.

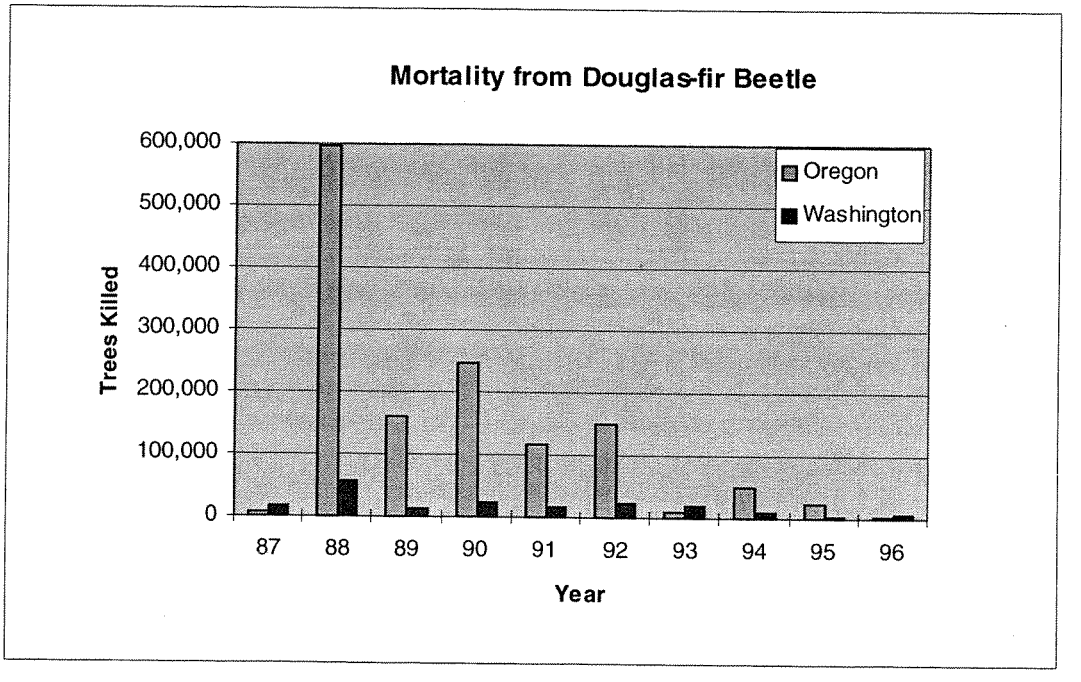
INSECT DAMAGE

Pine Bark Beetles. Pine mortality from mountain and western pine bark beetles declined throughout much of the Pacific Northwest, most likely due in part to increased rainfall in 1995 which lessened moisture stress and susceptibility of trees to beetle attack. High stand density in many areas, however, continues to predispose stands to pine bark beetle infestations.

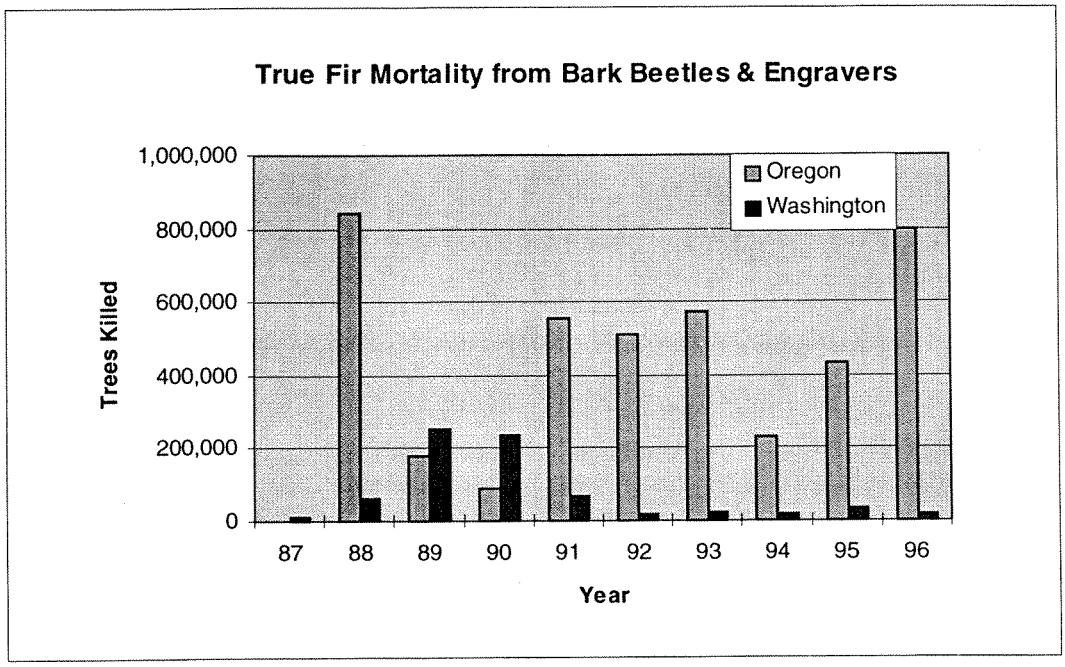
Several severe snow and ice storms occurred in the late fall and winter of 1996, especially in northeast Washington. Many of the pines injured in these storms will be attacked by mountain pine beetle the following year and mortality will be visible in 1998.



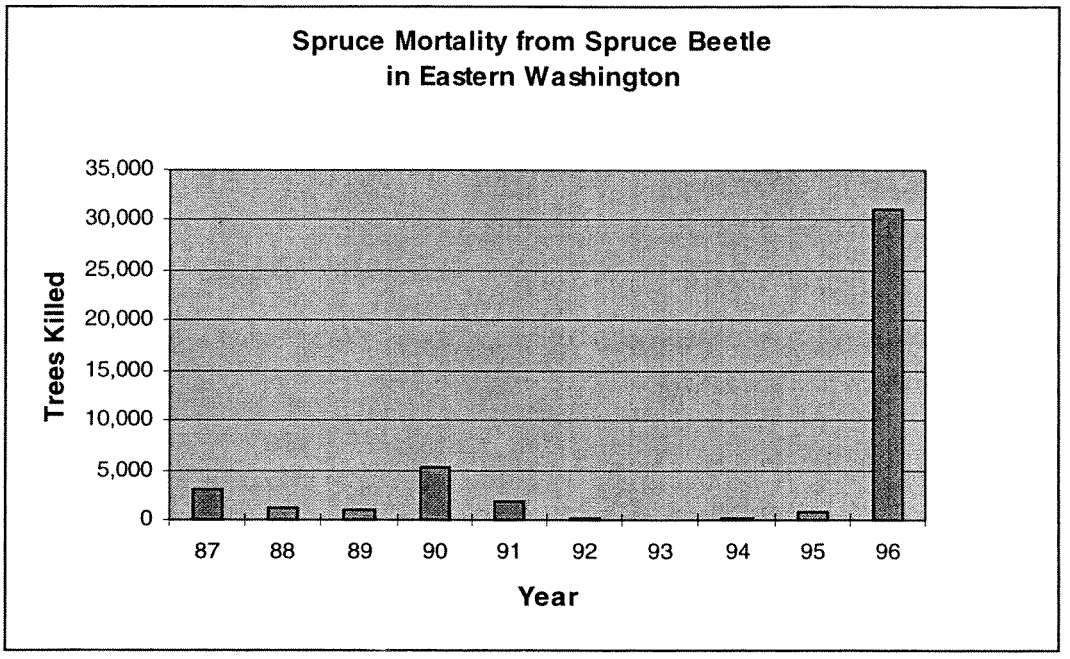
Douglas-fir Beetle. Similarly, numbers of Douglas-fir killed by Douglas-fir beetle decreased in 1996. However, Douglas-fir beetle habitat created by numerous recent fires likely will result in beetle population increases in 1997. Increased beetle-caused mortality is also expected in the summer of 1998 due to the windstorms in the winter of 1995 and 1996 and extensive flooding in February 1996 which damaged many large diameter Douglas-fir.



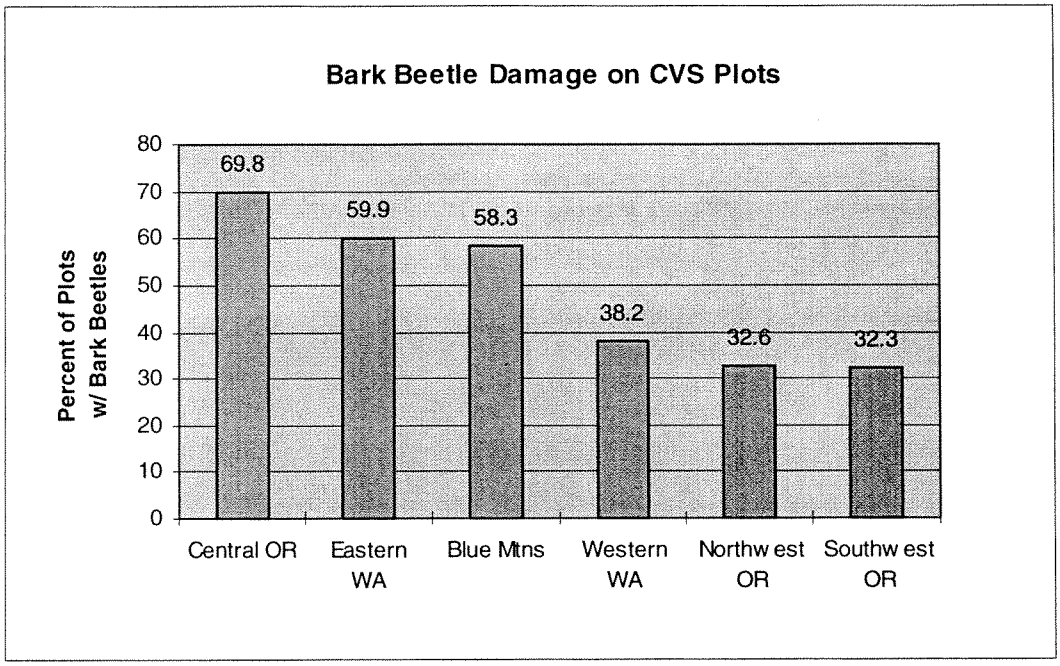
Fir Engraver Beetle. Mortality of true fir from fir engraver beetles was detected on fewer acres but with higher numbers of trees killed per acre. In 1995, less than one tree per acre was killed on 573,600 acres; in 1996, over two trees per acre were killed, but only on 377,600 acres. Despite 2 years of approximately normal precipitation, outbreaks of fir engraver have continued in areas which experienced drought, defoliation, or are infected with root disease. Many of the most heavily infested areas are pine sites which, due to selective logging and fire exclusion, now have a large component of true fir.



Spruce Beetle. Engelmann spruce mortality from spruce beetle increased from about 7,000 trees killed in 1995 to almost 32,000 in 1996. Over 90 percent of all trees killed by spruce beetle were in the Pasayten Wilderness of the Okanogan National Forest. Ground-checking found that some of the spruce mortality was caused by *Ips* species as well as spruce beetle. In other areas, spruce beetle mortality was lightly scattered; low levels of spruce beetle activity are due, in part, to the gradual removal of spruce by previous infestations.

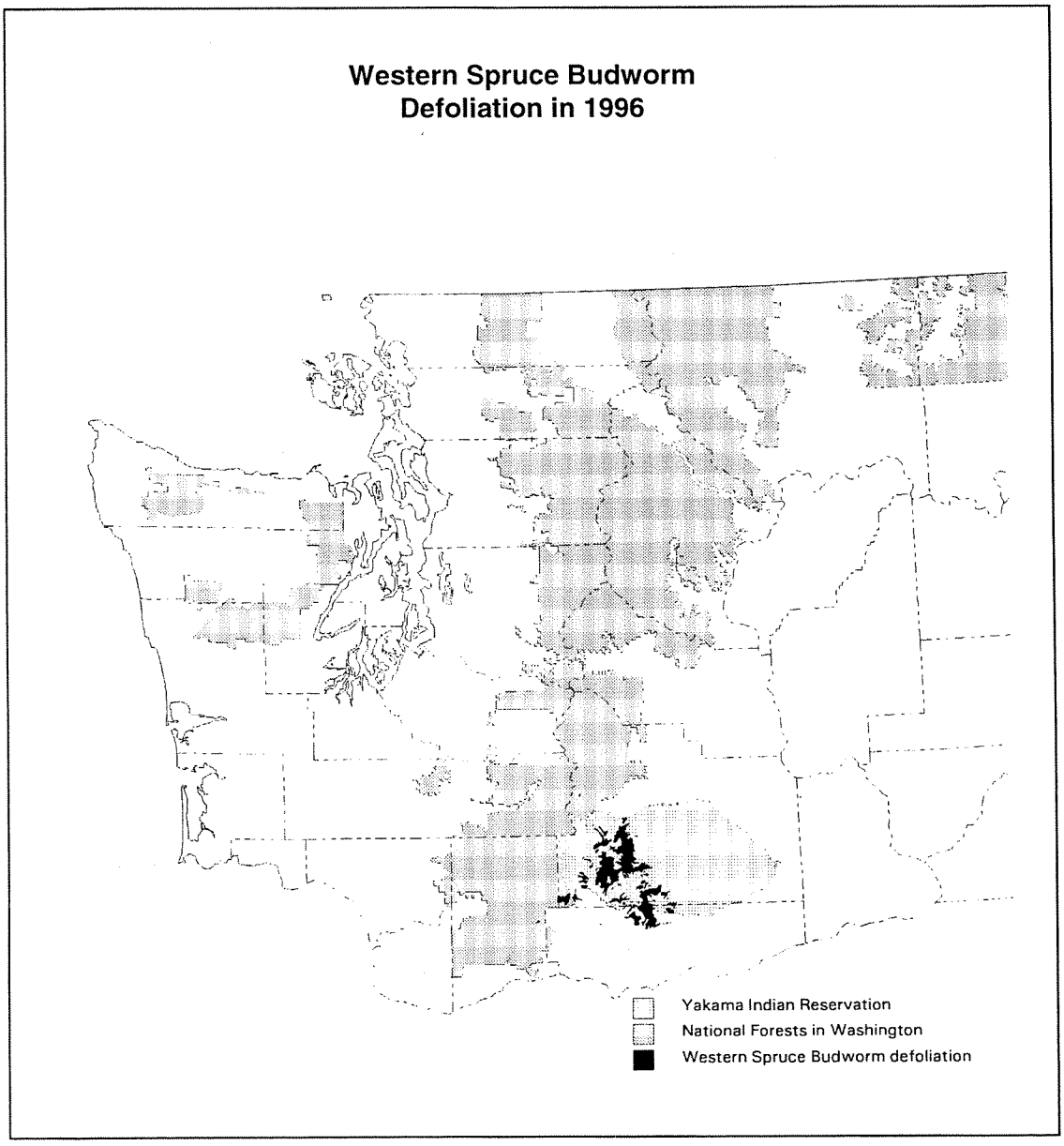


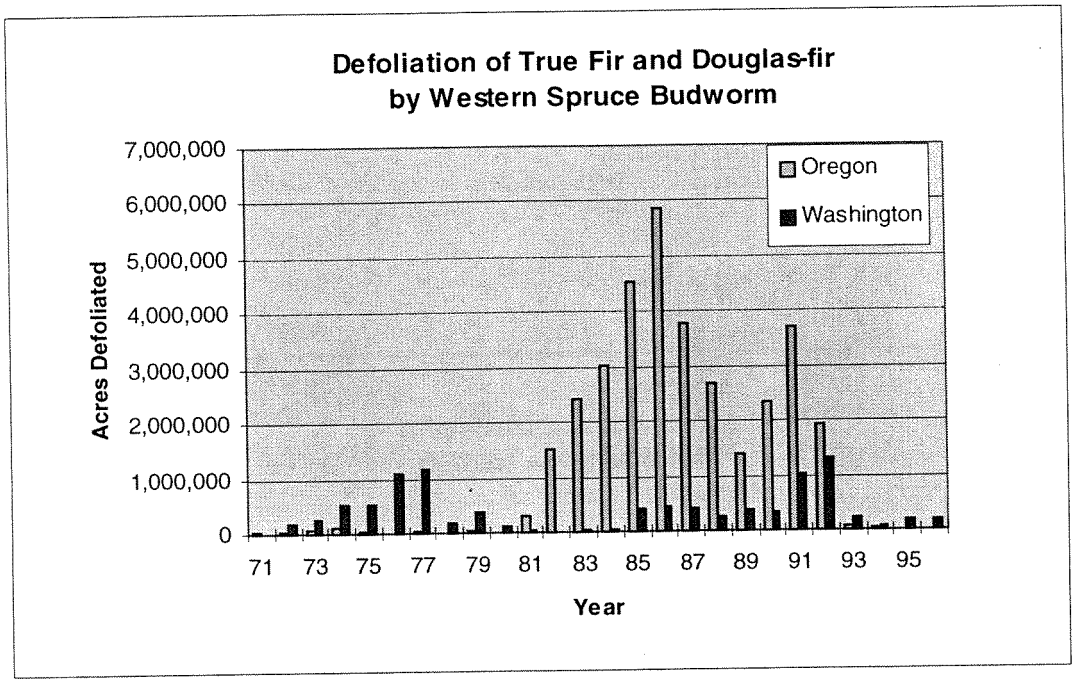
All Bark Beetles. Bark beetle data is also collected on CVS plots on national forests in Oregon and Washington. CVS data collected in 1993 and 1994 show the following incidence of bark beetle damage.



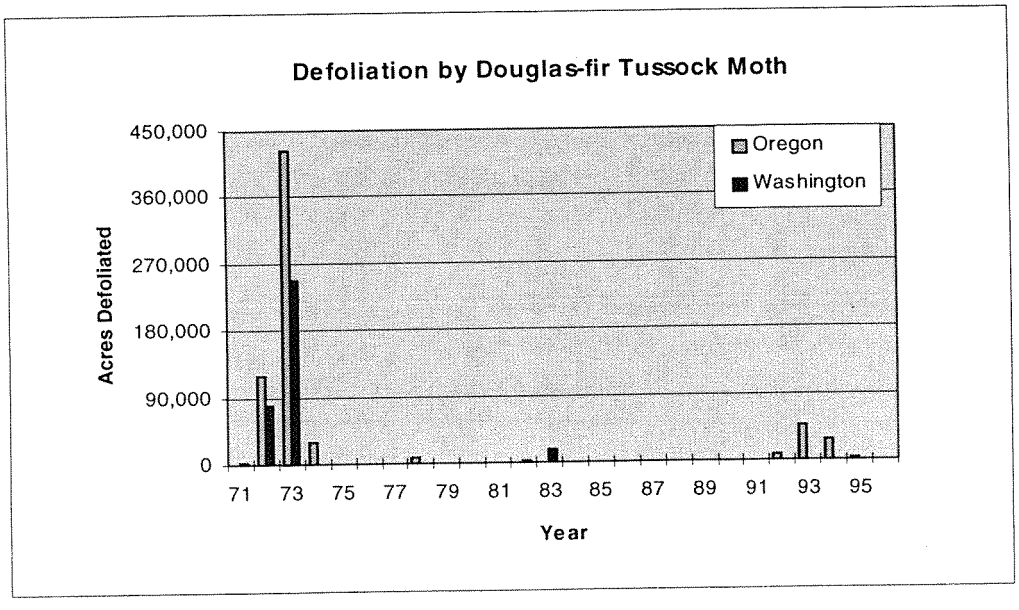
	% Plots with bark beetles	*% Trees with bark beetles*
Oregon		
Northwest OR plots	32.6	1.3
Southwest OR plots	32.2	1.0
Central OR plots	69.8	6.5
Blue Mountain OR plots	58.3	4.9
All OR plots	52.8	3.9
Washington		
Eastern WA plots	59.9	2.7
Western WA plots	38.2	1.2
All WA plots	45.7	1.7
All OR & WA plots	*51.4*	*3.3*

Western Spruce Budworm. Areas of visible defoliation by western spruce budworm, a common defoliator of Douglas-fir and true firs, decreased slightly from 1995. Since 1993, budworm populations and defoliation have declined significantly regionwide. Budworm-caused defoliation was detected only in Washington in 1996.

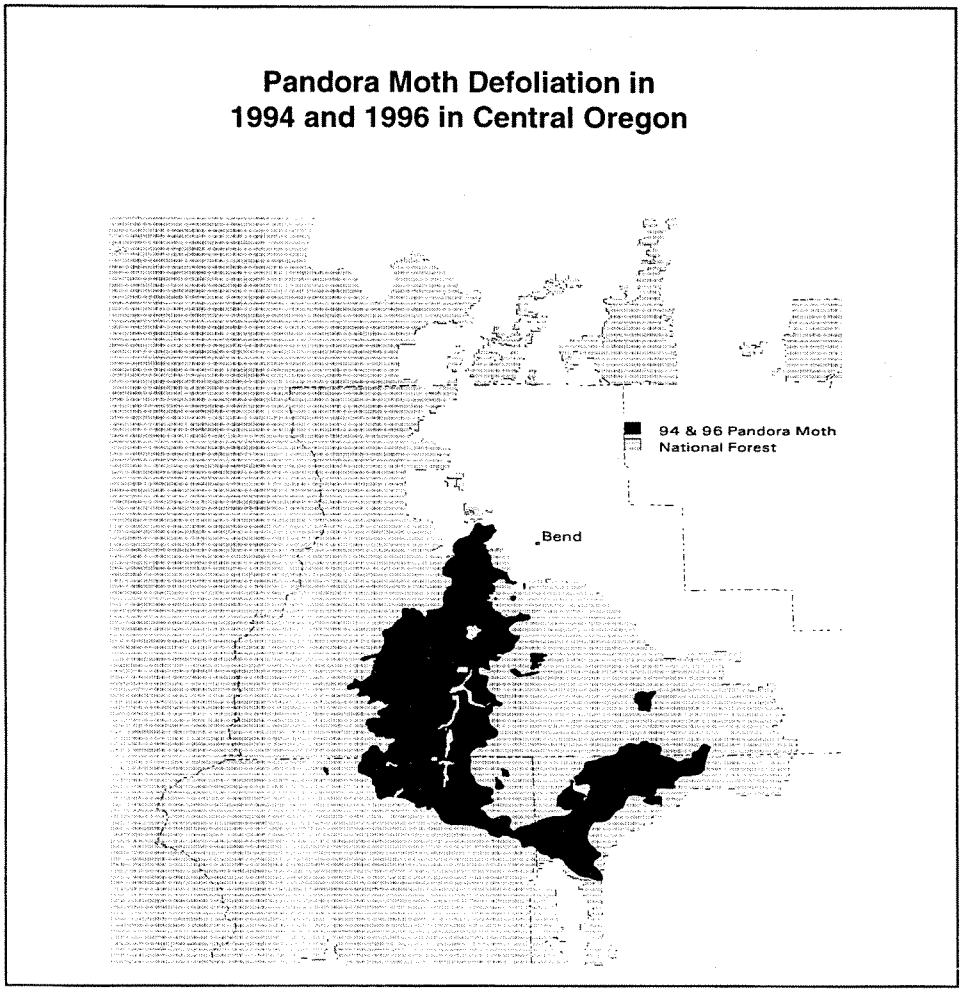




Douglas-fir Tussock Moth. No defoliation by Douglas-fir tussock moth, another defoliator of Douglas-fir and true firs, was detected in 1996.

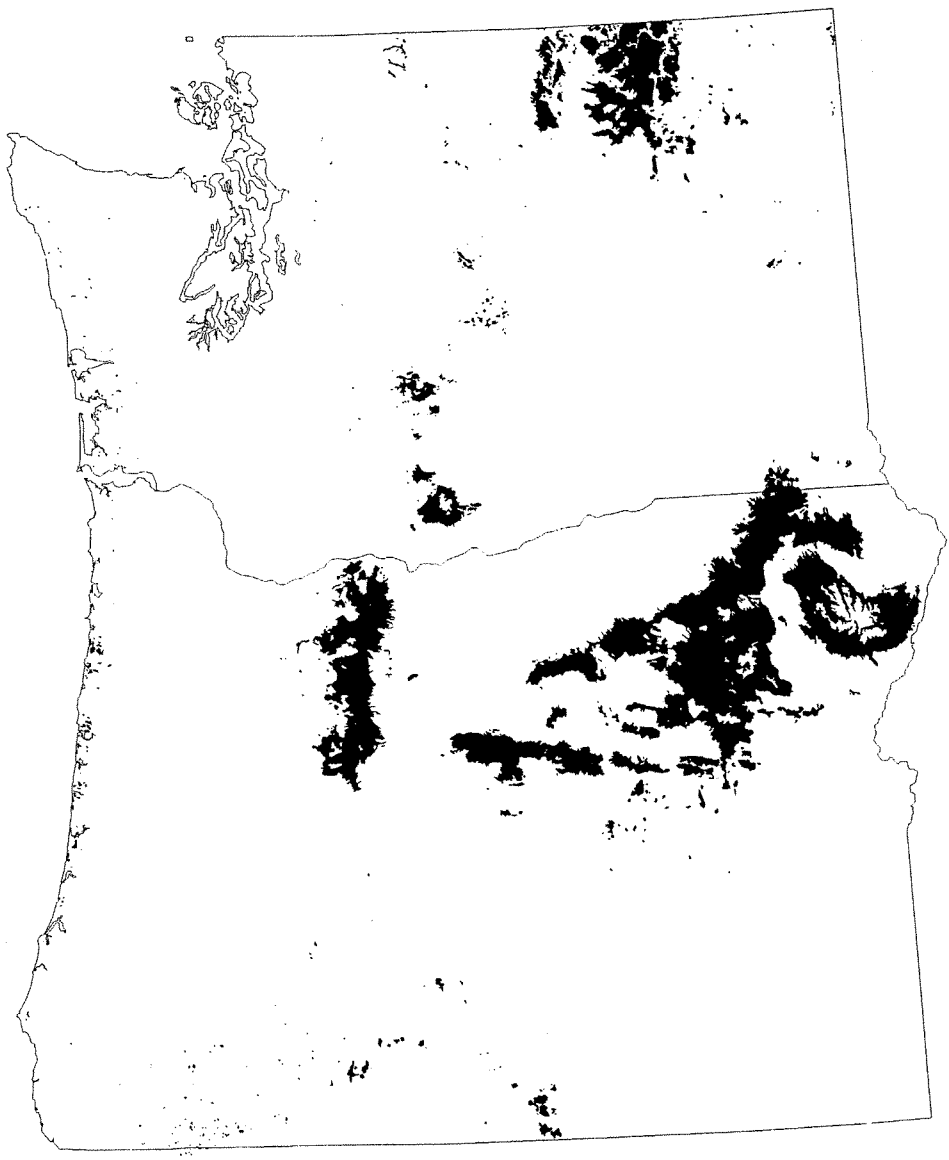


Pandora Moth. Pandora moth *(Coloradia pandora)* defoliated only 12,300 acres in 1996. The current pandora moth infestation began in 1986 and grew with each successive generation until it peaked in 1994 with almost 370,000 acres showing some level of defoliation. A naturally occurring virus was noted throughout the infested area in 1994 and is thought to be responsible for the collapse of the population.

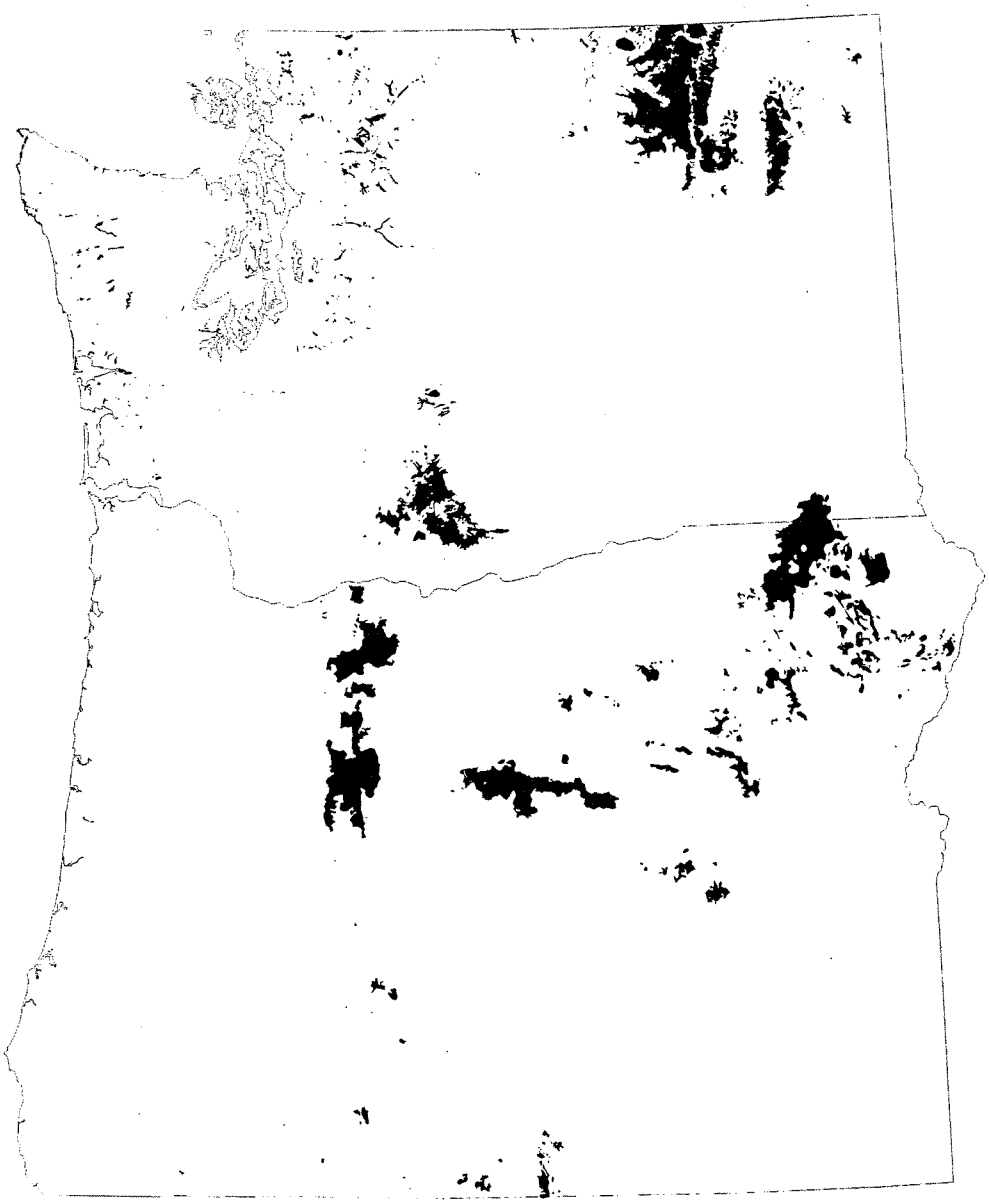


All Defoliating Insects. Insect-caused defoliation (primarily western spruce budworm) was observed during aerial survey on over 206,000 acres in 1996, a small decrease from 1995. Overall defoliation (by all defoliating agents) however, has decreased significantly in the last 5 years (1992-96) compared to the previous 5 years (1987-91). See "Cumulative Defoliation" maps on next 2 pages.

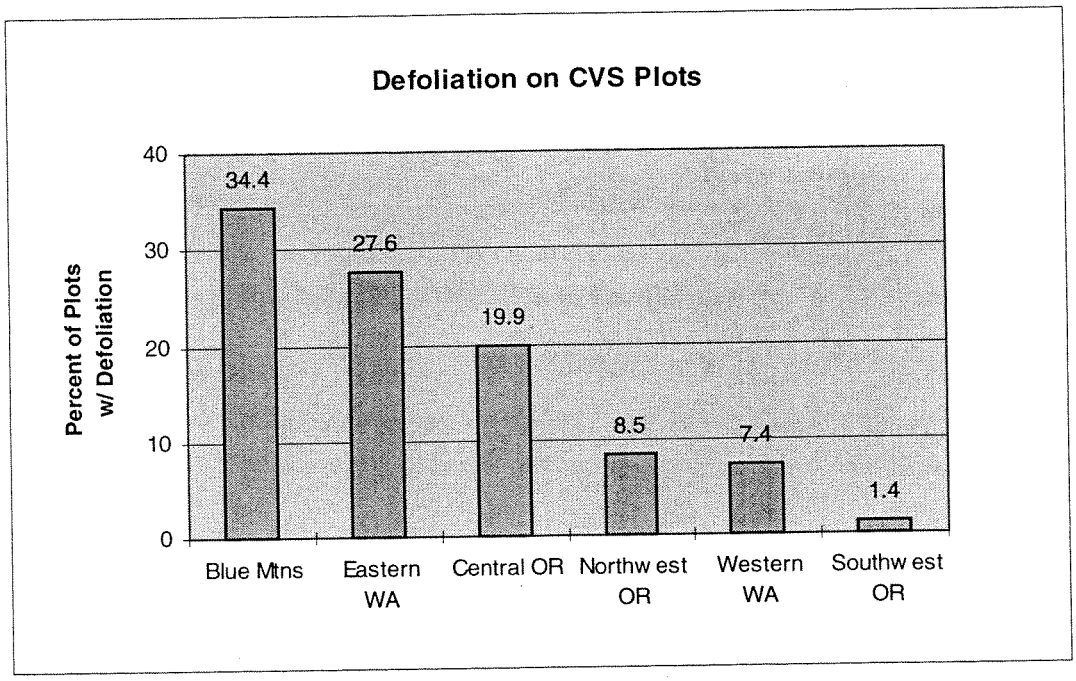
Cumulative Defoliation 1987-1991



Cumulative Defoliation 1992-1996



Plot-level defoliation data is also collected on CVS plots on national forests in Oregon and Washington. The majority of defoliation observed on CVS plots is insect-caused, although some of it may be caused by other agents such as weather or disease. CVS data collected in 1993 and 1994, show the following incidence of defoliation:

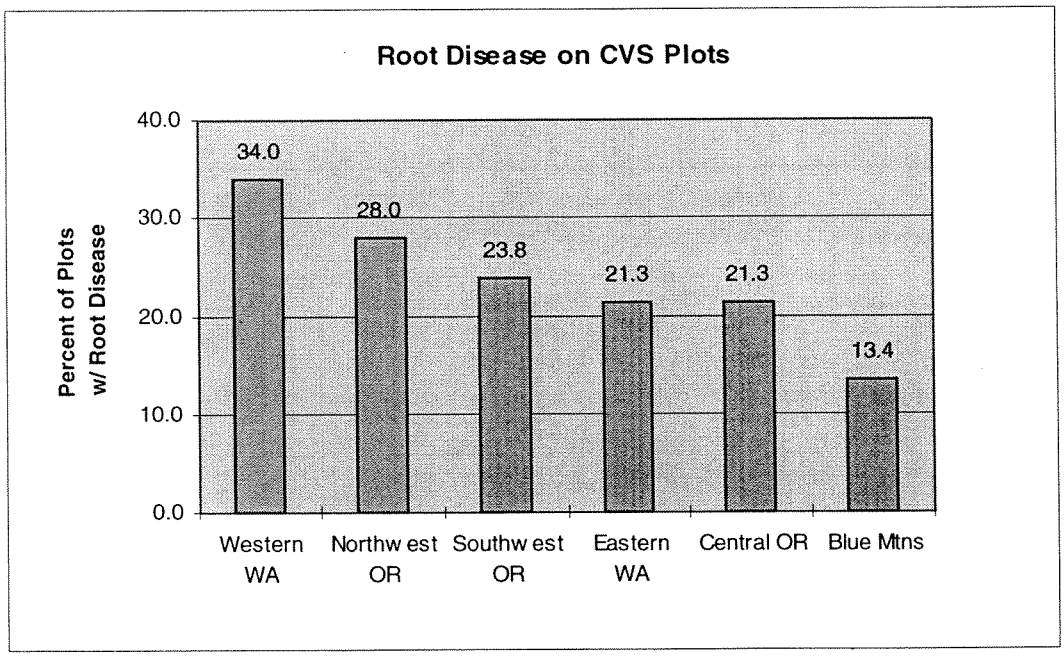


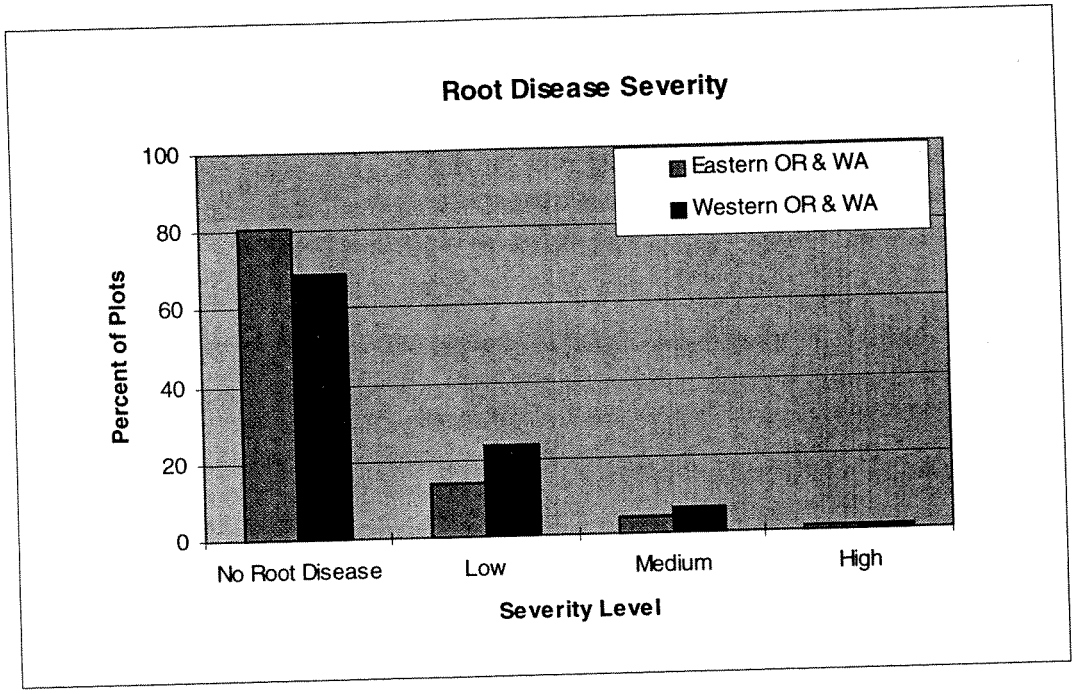
	% Plots with defoliation	*% Trees with defoliation*
Oregon		
Northwest OR plots	8.5	2.6
Southwest OR plots	1.4	0.1
Central OR plots	19.9	4.2
Blue Mountains OR plots	34.4	8.6
All OR plots	21.3	5.1
Washington		
Eastern WA plots	27.6	5.8
Western WA plots	7.4	0.8
All WA plots	14.4	2.5
All OR & WA plots	*19.9*	*4.4*

DISEASE DAMAGE

In general, native diseases of forest trees are slow to spread and intensify. Most native diseases do not cause the dramatic landscape level mortality or defoliation that is often associated with large-scale insect outbreaks and their effects are rarely considered catastrophic (an exception to this is the current Swiss needle cast outbreak on the Coast – see below). However, disease effects can be highly significant when looked at over large areas or over a long period of time.

Root Disease. Root disease, caused by several species of fungi, is the most significant disease that causes tree mortality in the Pacific Northwest. Root disease data is collected on CVS plots on national forests in Oregon and Washington. Signs and symptoms of root disease (dead trees, conks, yellowing, stress cone crops) indicate the presence of root disease. CVS data collected in 1993 and 1994, show the following incidence of root disease.





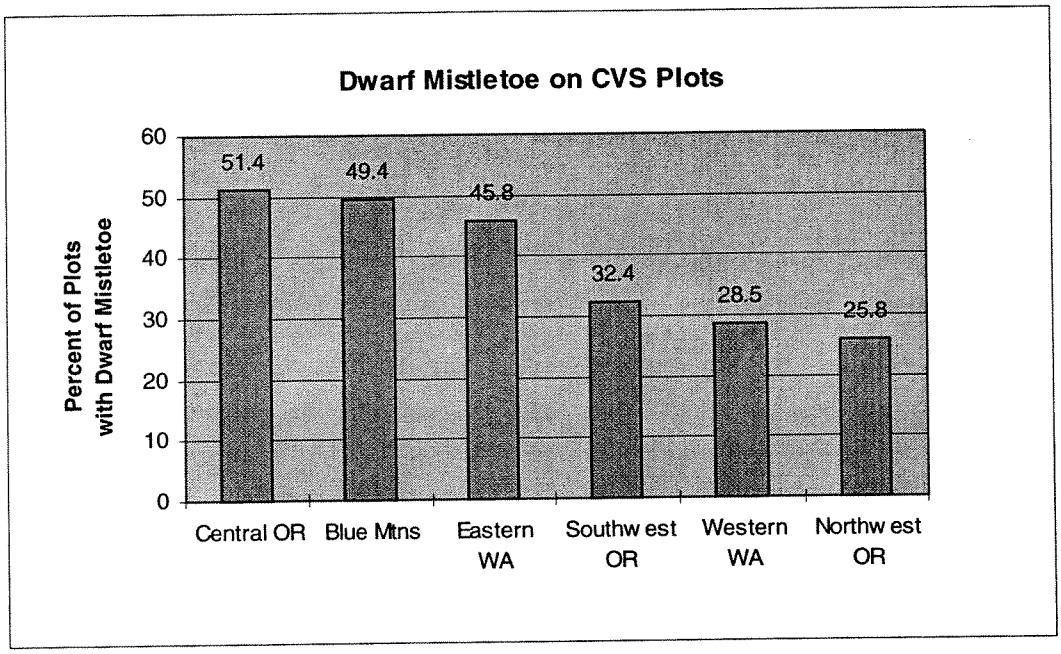
	% Plots with root disease	*% Trees with root disease*
Oregon		
Northwest OR plots	28.0	1.4
Southwest OR plots	23.8	0.7
Central OR plots	21.3	2.2
Blue Mountain OR plots	13.4	1.6
All OR plots	19.8	1.6
Washington		
Eastern WA plots	21.3	1.2
Western WA plots	34.0	1.2
All WA plots	29.6	1.2
All OR & WA plots	*21.7*	*1.5*

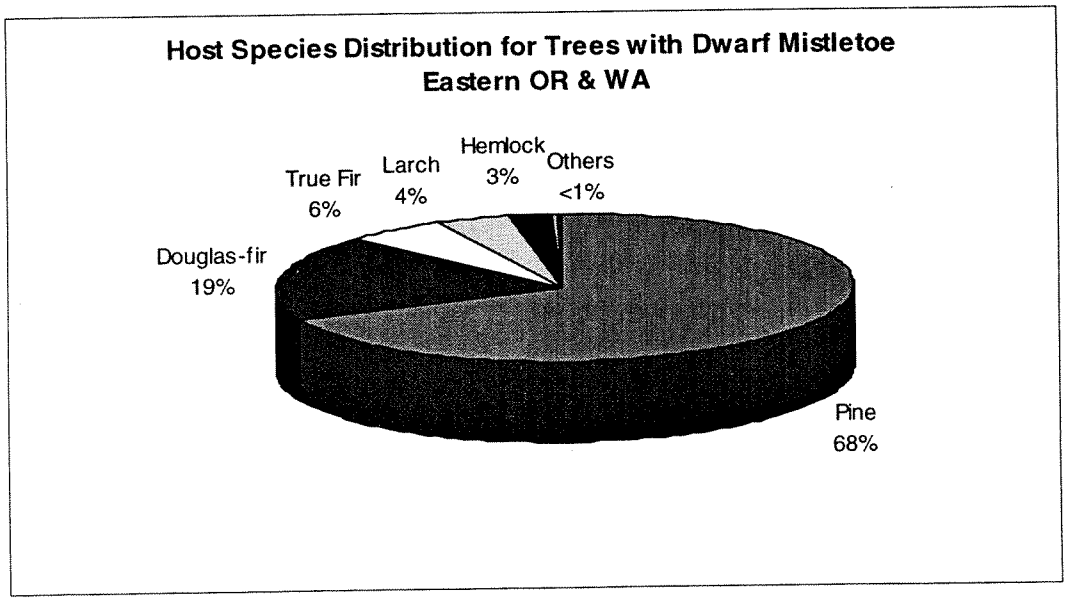
Swiss Needle Cast. Swiss needle cast is a native disease of Douglas-fir foliage, common west of the Cascades. Over the last 15 years, increased symptoms of the disease (yellowing, needle loss, and growth reductions) have been observed in coastal Douglas-fir plantations. A special aerial survey for Swiss needle was conducted for the first time in 1996 (in April and May, prior to the annual aerial survey done July-September) along the coast of Oregon. Approximately 130,000 acres of discolored Douglas-fir were mapped. Swiss needle cast is also present in western Washington but at much less damaging levels.

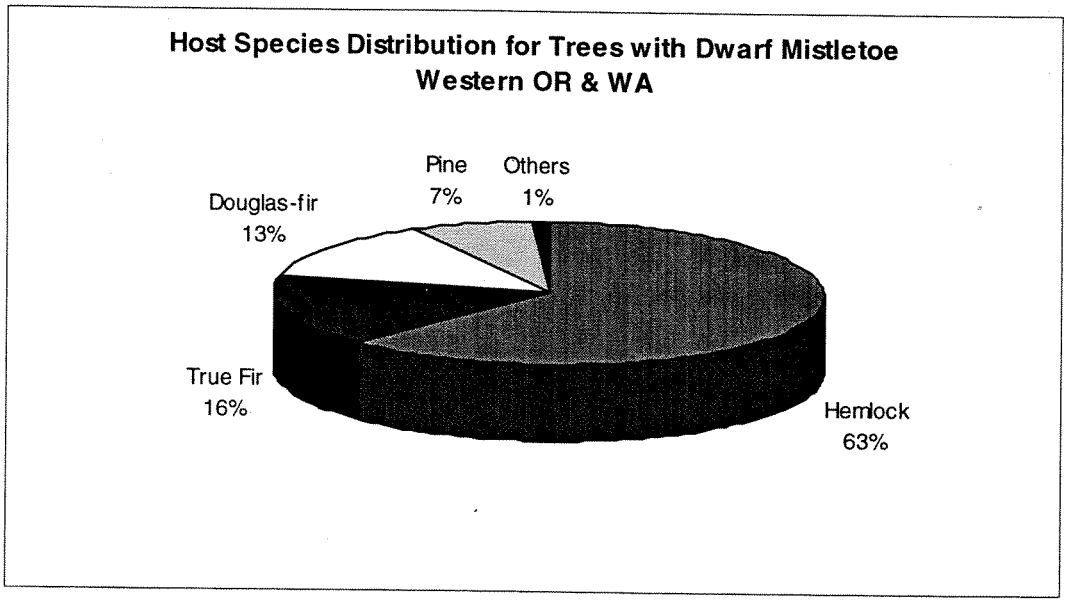
Swiss Needle Cast

Other needle diseases, such as larch needle diseases and lodgepole pine needle cast, were more prevalent east of the Cascades and in southwest Oregon in 1996, likely due to higher than normal precipitation in the spring and early summer.

Dwarf Mistletoes. Dwarf mistletoes are parasitic plants that infect conifer species and cause growth loss, topkill, distortion, and mortality in host trees. Dwarf mistletoes also are recognized for their ecological value, providing food and habitat for wildlife. Data from CVS plots on national forests in Oregon and Washington, collected in 1993 and 1994, show the following incidence and severity of dwarf mistletoe on national forests:







	% Plots with dwarf mistletoe	*% Trees with dwarf mistletoe*
Oregon		
Northwest OR plots	25.8	4.2
Southwest OR plots	32.4	5.0
Central OR plots	51.4	14.5
Blue Mountains OR plots	49.4	4.9
All OR plots	42.9	7.6
Washington		
Eastern WA plots	45.8	5.3
Western WA plots	28.5	3.8
All WA plots	40.2	4.3
All OR & WA plots	*41.3*	*6.7*

ANIMAL DAMAGE

Bears. Tree damage, including mortality, occurs when bears peel the bark on the trunk of the tree, partially or completely girdling it, to feed on newly forming wood and innerbark. A special aerial survey conducted by the Oregon Department of Forestry for bear damage in western Oregon showed more acres with mortality due to bears in 1996 (62,614) than in the previous 4 years (average of 39,810).

The number of trees killed by bears in western Washington also increased in 1996. The cooperative aerial survey mapped 32,010 bear-killed trees in 1996 in western Washington compared to 23,716 in 1995–about a 35 percent increase.

EXOTIC PEST DAMAGE

Exotic (nonnative) insects, diseases, and plants are continuously introduced into Oregon and Washington, transported primarily by trade and movement of people. Over the years, a number of these exotics have become established in northwest forests. Some, such as gypsy moth, are not yet established.

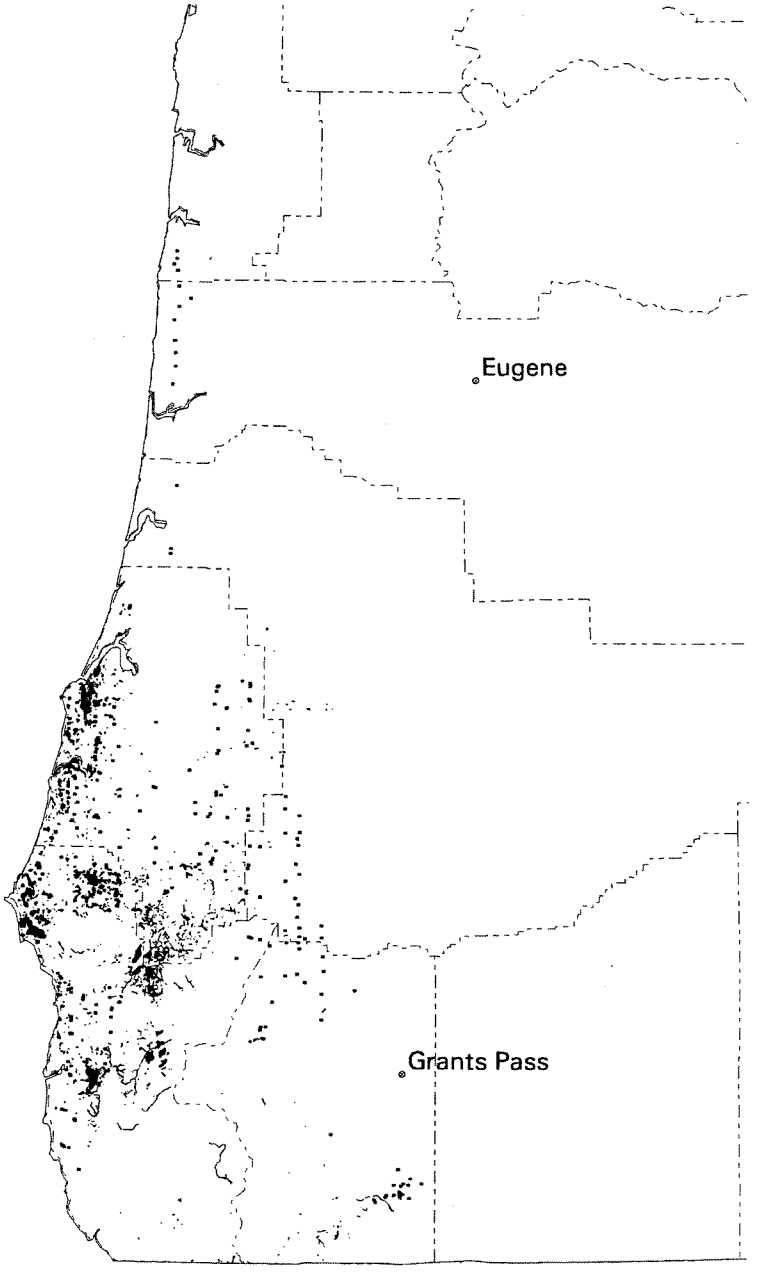
Exotic Forest Pests Established in Oregon and Washington		
Diseases	Insects	Noxious Weeds
Dogwood anthracnose Dutch elm disease Melampsora leaf rust Port-Orford-cedar root disease White pine blister rust	Balsam woolly adelgid Larch casebearer Satin moth	Scotch broom Gorse Spotted knapweed Tansy ragwort Yellow starthistle (and many more)

Exotic Diseases. Two nonnative diseases, white pine blister rust and Port-Orford-cedar root disease, have caused extensive mortality of host trees and, in many areas, have altered forest ecosystems by removing a large proportion or certain size class of the host species.

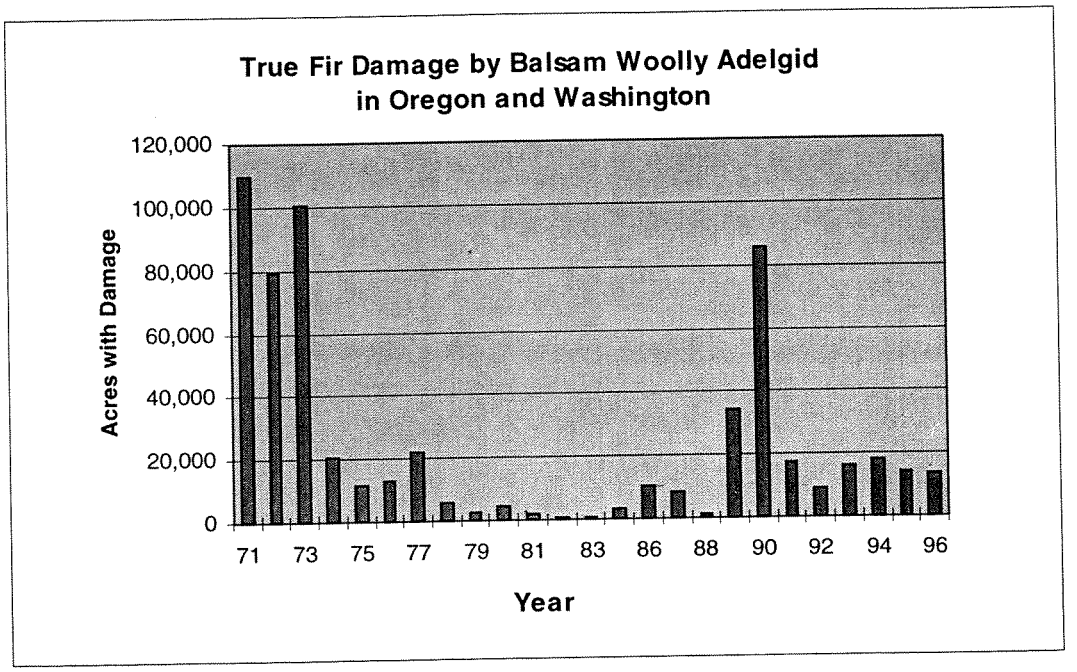
White pine blister rust causes topkill, branch flagging, and mortality throughout the range of western white pine, sugar pine, and whitebark pine. Despite availability of rust resistant seedlings, the health and survival of five-needle pines is a serious concern in some locations, such as high elevation stands, high hazard sites, and overstocked stands where mortality is high due to a combination of blister rust and bark beetles. Beginning in 1994, an attempt was made to map blister rust during the aerial survey. Although blister rust is extensive throughout the range of five-needle pines, only 4,700 acres were mapped in 1996 due to the difficulty in observing nonlethal symptoms (such as branch flagging) and in distinguishing blister rust mortality from mountain pine beetle mortality.

In southwest Oregon, Port-Orford-cedar root disease is present on over 33,000 acres, especially in wet areas, along streams, and where infected water or soil has been carried downslope from roads. On national forest lands, slightly less than 10 percent of all Port-Orford-cedar is infected. Although survival of Port-Orford-cedar is not in jeopardy, loss of older and larger Port-Orford-cedar trees has changed the composition and structure of many stands. Over 1,800 recently-killed Port-Orford-cedar were mapped in 1996 during both a special mortality survey in June by Oregon Department of Forestry and the regular aerial survey late in the summer. (Ground checking has shown, however, that some of this mortality is due to bear damage.)

Port-Orford-Cedar Root Disease in Southwest Oregon



Exotic Insects. Balsam woolly adelgid, satin moth, and larch casebearer have been established in northwest forests for a number of years. The balsam woolly adelgid, a sucking insect, infests the bole, twigs or branches of true fir and continues to cause serious damage since its introduction to the Pacific Northwest in the 1930s. Over 13,000 acres with balsam woolly adelgid damage were detected in 1996, primarily in the western Cascades in Washington.



Satin moth defoliation of aspen was detected on 196 acres in northeast Washington, a decrease from 4,548 acres in 1995.

After years of negligible damage, larch casebearer-caused defoliation of western larch was observed in portions of the Blue Mountains in 1996. Introduced parasites, released and established years ago, along with needle diseases on larch, have helped maintain low levels of casebearer for many years. As casebearer populations declined, so did the introduced parasites. Parasites are expected to respond to the increasing casebearer population, although there may be several more years of defoliation before they increase to effective levels.

Gypsy moths, both European and Asian, continue to be trapped at various locations in the northwest. These trap catches represent either new introductions or populations not completely eradicated by previous treatments. In 1996, 173 moths were trapped, 42 in Oregon and 131 in Washington. Of the 173 moths, one was identified as the Russian Far East strain of the Asian gypsy moth and the remainder were identified as European strain moths. In addition, in early summer, one Asian moth larva was found at a port facility where the adult was subsequently caught.

Because gypsy moth is a very damaging defoliator of hardwoods (European and Asian strains) and conifers (Asian strain only) and is not yet established in Oregon and Washington, populations of the moth are eradicated when traps indicate a viable population. One eradication project in Oregon (10 acres in Gresham, Multnomah County) and eight projects in Washington (21,856 acres in Clark, King, Pierce, and Thurston Counties) were carried out in 1996.

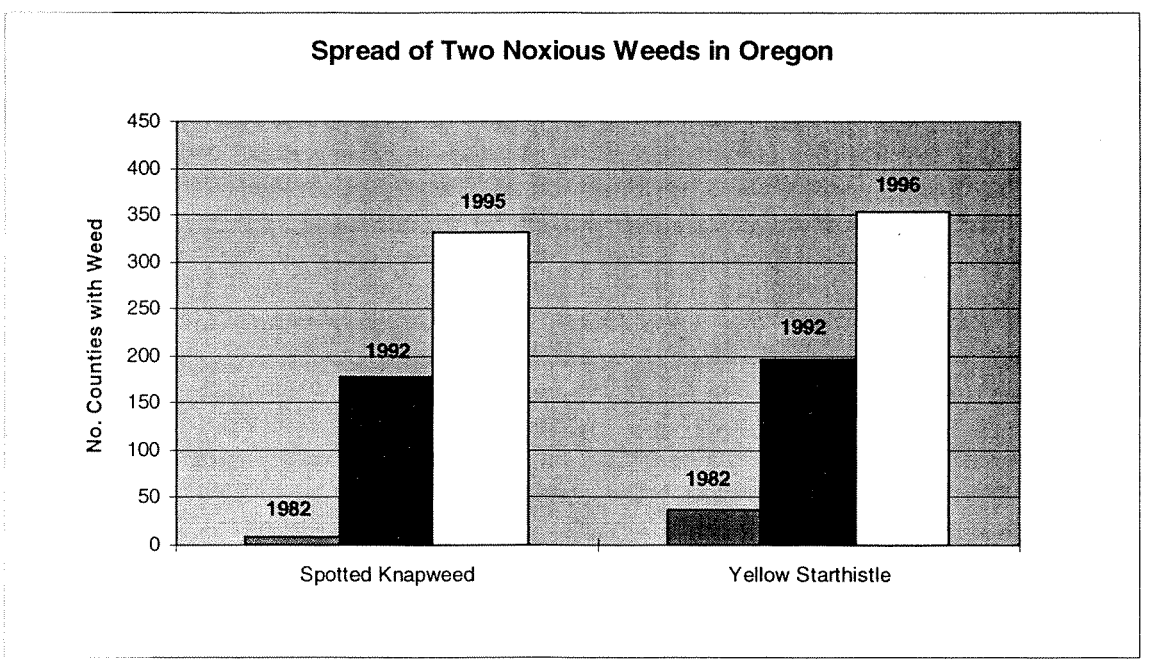
New introductions are expected to continue as long as moth populations persist elsewhere (Europe, Asia, eastern United States) and as long as people and products move from these infested areas to the Pacific Northwest.

Xyloborinus alni, an Asian ambrosia beetle, was detected in the ports of Olympia and Tacoma, Washington, in 1996. This beetle tunnels into larch and alder trees.

Noxious Weeds. One group of exotic pests, noxious weeds, is a mounting problem in the forests and rangelands of Oregon and Washington. Many noxious weeds have spread dramatically over the past decade or two. Invasion by nonnative plants results in competition with native vegetation and, frequently, alteration of the physical and biological environment. Organisms dependent on native plants and adapted to a particular environment are also affected. Noxious weeds are controlled by chemical, mechanical, and biological means. Biological control agents have been successful on a number of noxious weeds in various locations.

Inventories for 1996 estimate that 509,000 acres of national forests in Oregon and Washington are infested with ecologically significant amounts of one or more noxious weeds:

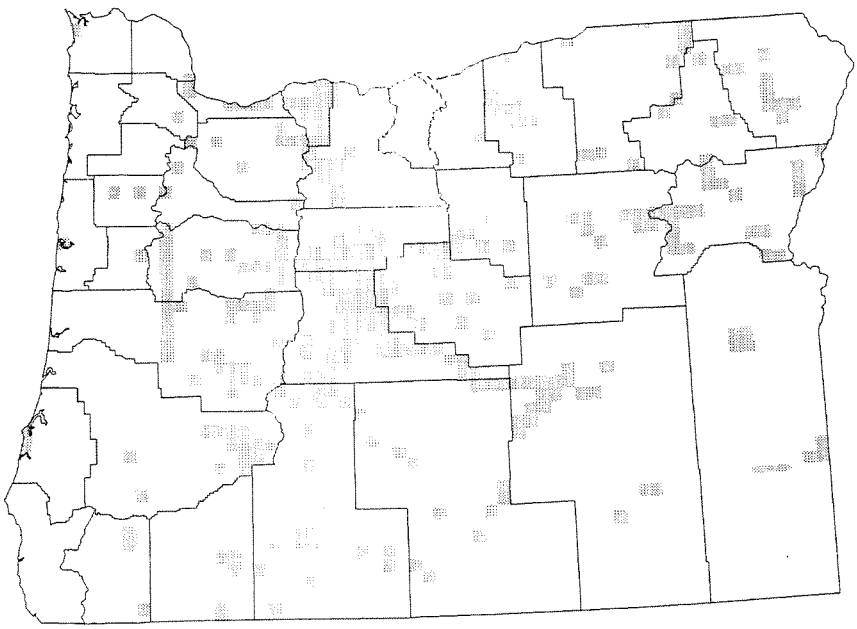
Oregon national forests - 317,000 acres
Washington national forests - 192,000 acres



The following information was provided by the Oregon Department of Agriculture. Similar information was not available from Washington, although noxious weed spread and impact are similar in the two states.

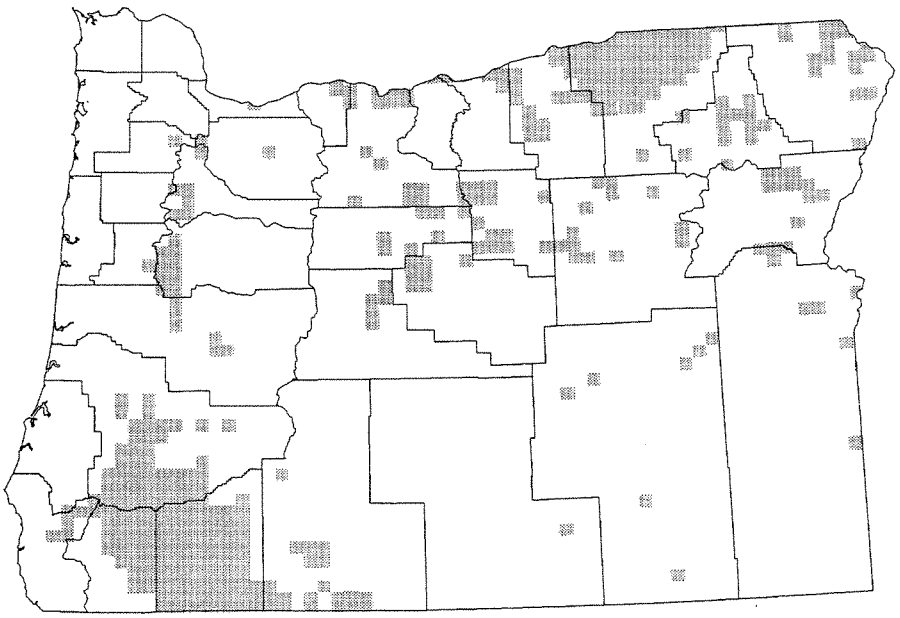
Spotted knapweed is a major concern in Oregon. It is a very aggressive invader of range and forest lands, displacing native plants and reducing biodiversity on many sites. Spotted knapweed, like many knapweeds, is a real "road runner," spreading along roads via vehicles and equipment. It then moves into forests and rangelands from the roads. The largest population of this weed is in central Oregon. It is also spreading along highways into western Oregon forests.

Spotted Knapweed



Yellow starthistle is an annual weed in the knapweed family that produces large amounts of seed and spreads very rapidly. The large core infestations of this weed are in southern (Jackson, Josephine, and Douglas Counties) and northeastern Oregon (counties bordering the Columbia River from Wasco County on the west to Umatilla County on the east). Yellow starthistle is a particular problem in rangelands but is also found in forested areas. Like other knapweeds, it is extremely aggressive and can form dense stands displacing the native plant community.

Yellow Starthistle



Gorse, a shrubby legume, is widely established and persistent in Coos and Cury counties and in coastal areas of Douglas and Lane Counties. Scattered small infestations are under treatment in Clatsop, Tillamook, Lincoln, Clackamas, Benton, Marion, Columbia, and Yamhill Counties as well as inland portions of Douglas and Lane Counties. It is aggessive, able to invade and dominate sites such as reforestation units, roadsides, recreational sites, pastures, and natural areas. Gorse is also an extreme fire hazard. It is believed that gorse has the same range as Scotch broom--primarily all lands in western Oregon and Washington below 3,000 feet.

Tansy ragwort is another introduced weed that has made substantial impacts in Oregon and Washington's pasture, western range, and forest lands. It is widely distributed west of the Cascade Mountains, except in Jackson and Josephine Counties in Oregon, but is rarely a problem because of control by three biocontrol agents. Ragwort has been found growing to flower at more than 1,000 sites east of the Cascades and has the potential to become established there.

Scotch broom is a shrubby legume that is widespread in western Oregon and Washington. It is extremely competitive in reforestation units, along roadsides, pastures, and natural areas. Some isolated population of Scotch broom are now being detected in central and eastern Oregon, and eastern Washington.

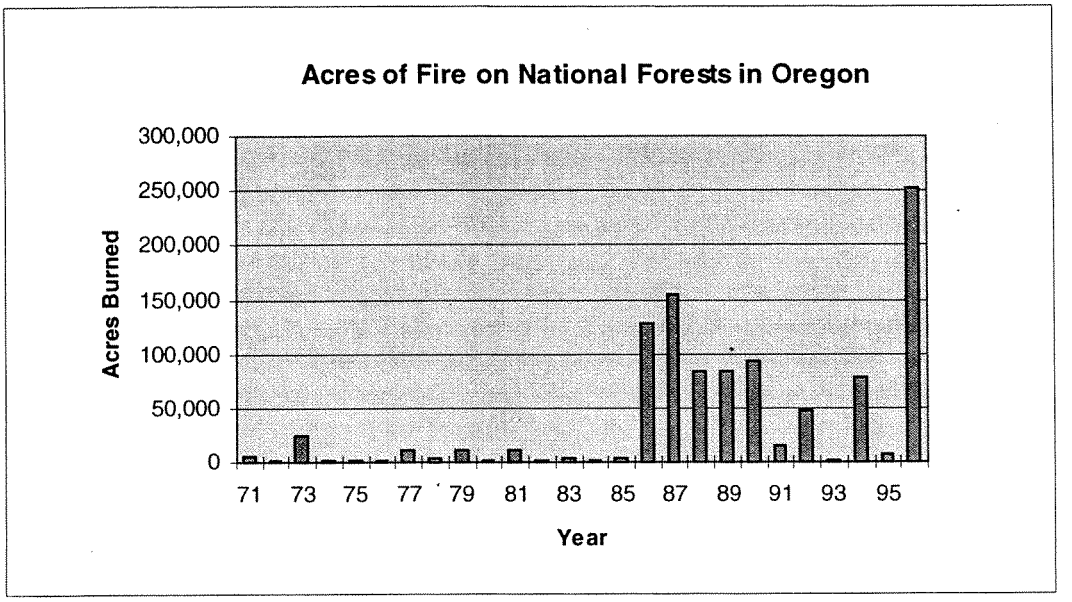
FIRE DAMAGE

Over 4,000 forest fires burned approximately 636,000 acres in Oregon and Washington (state and federal lands) in 1996. This represents about 11 percent of burned acres for the nation. The estimated volume of timber killed by fires on National Forest lands in 1996 was 1.13 billion board feet.

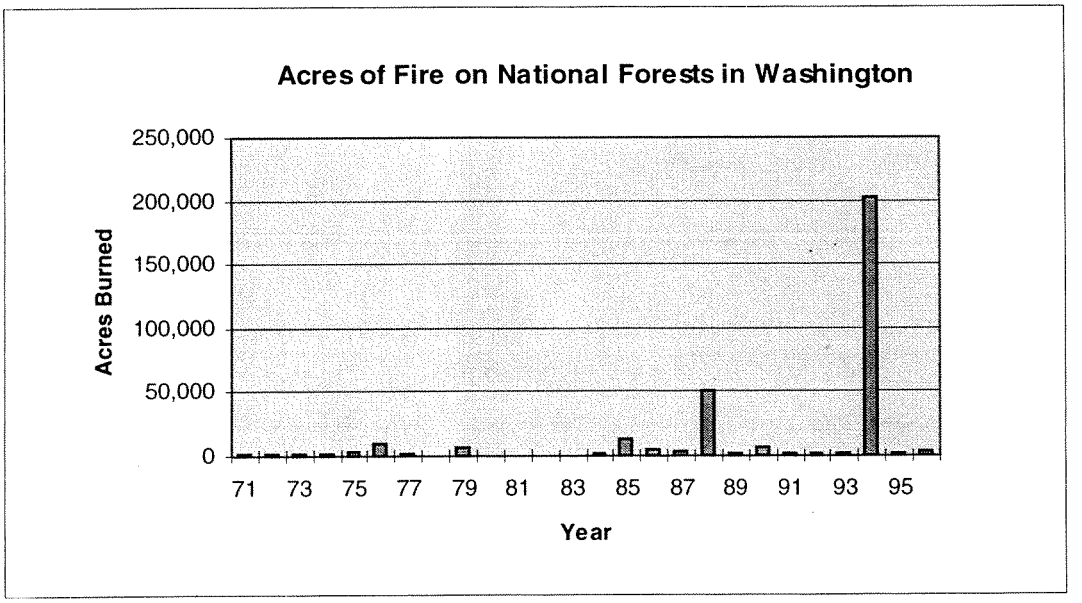
	BIA	*BLM*	*FWS*	*NPS*	*USFS*	*States**	*Totals*
Oregon							
No. Fires	82	457	14	19	1,421	1,128	3,121
No. Acres	121,400	191,101	1,400	74	252,270	25, 233	591,478
Washington							
No. Fires	148	33	14	35	191	774	1,195
No. Acres	20,350	14,322	21	9	4,004	6,485	45,191

* Oregon-ODF lands only; Washington-DNR lands only.

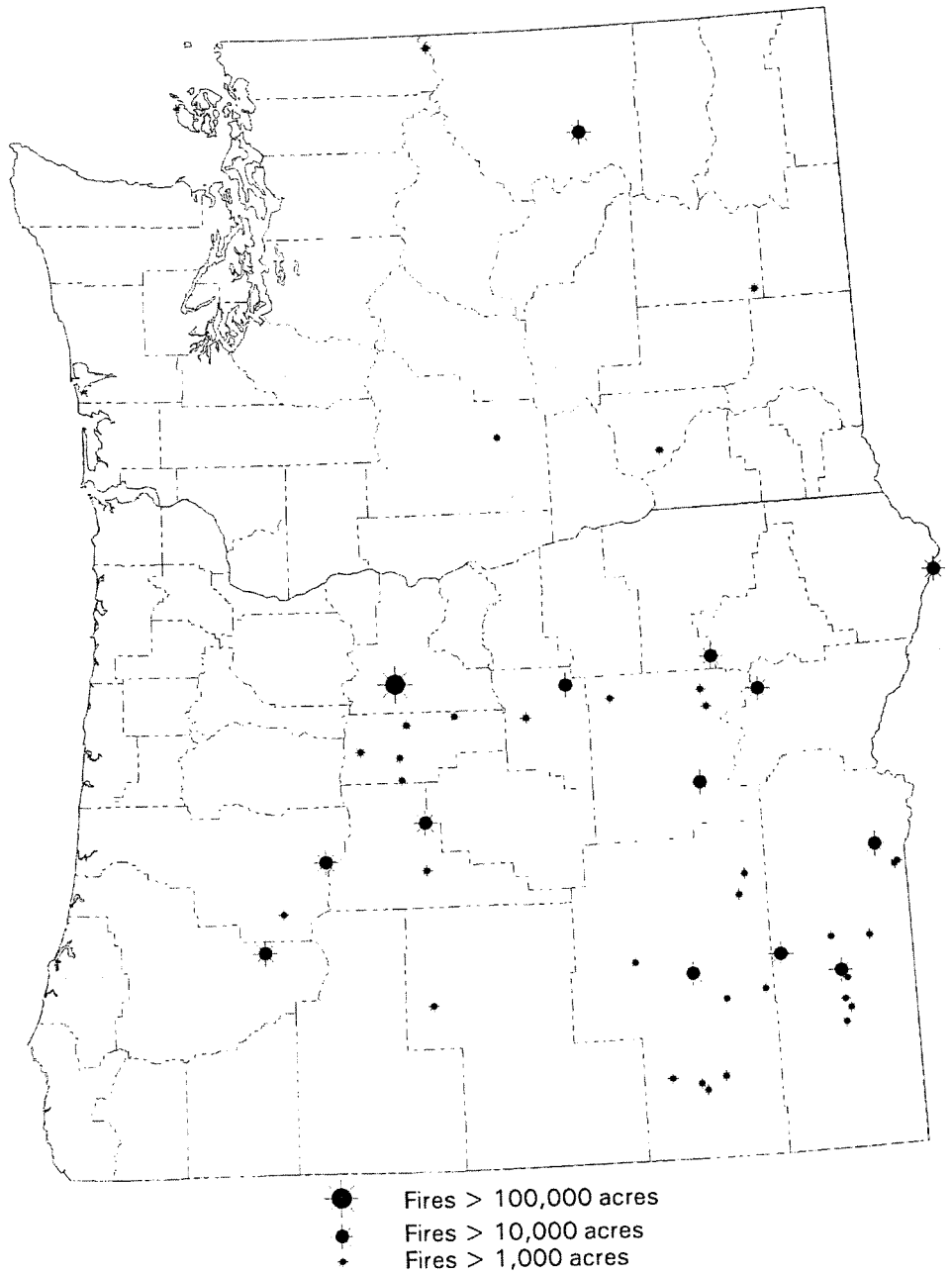
Oregon Fires. The 1996 fire season in Oregon was one of the most severe in recent history. Abundant winter and spring precipitation resulted in a longer than usual growing season for fine fuels. These fuels then dried out very quickly and, by early August, burning conditions were extremely favorable, particularly in eastern Oregon. Above normal temperatures and intense lightning activity during the months of July, August, and September resulted in numerous fires, many of them large.



Washington Fires. Conditions in eastern Washington were similar to Oregon but fewer large fires resulted. Few fires and few burned acres occurred in western Washington in 1996. Precipitation was high throughout May and June and the drying process for fine fuels was much slower so that favorable burning conditions were not reached until late August. Most significantly, there were very few lightning storms that tracked across western Washington and no periods of hot, dry, east winds in the Washington Cascades in the late summer or early fall.



Location of Forest Fires Greater Than 1,000 Acres in 1996

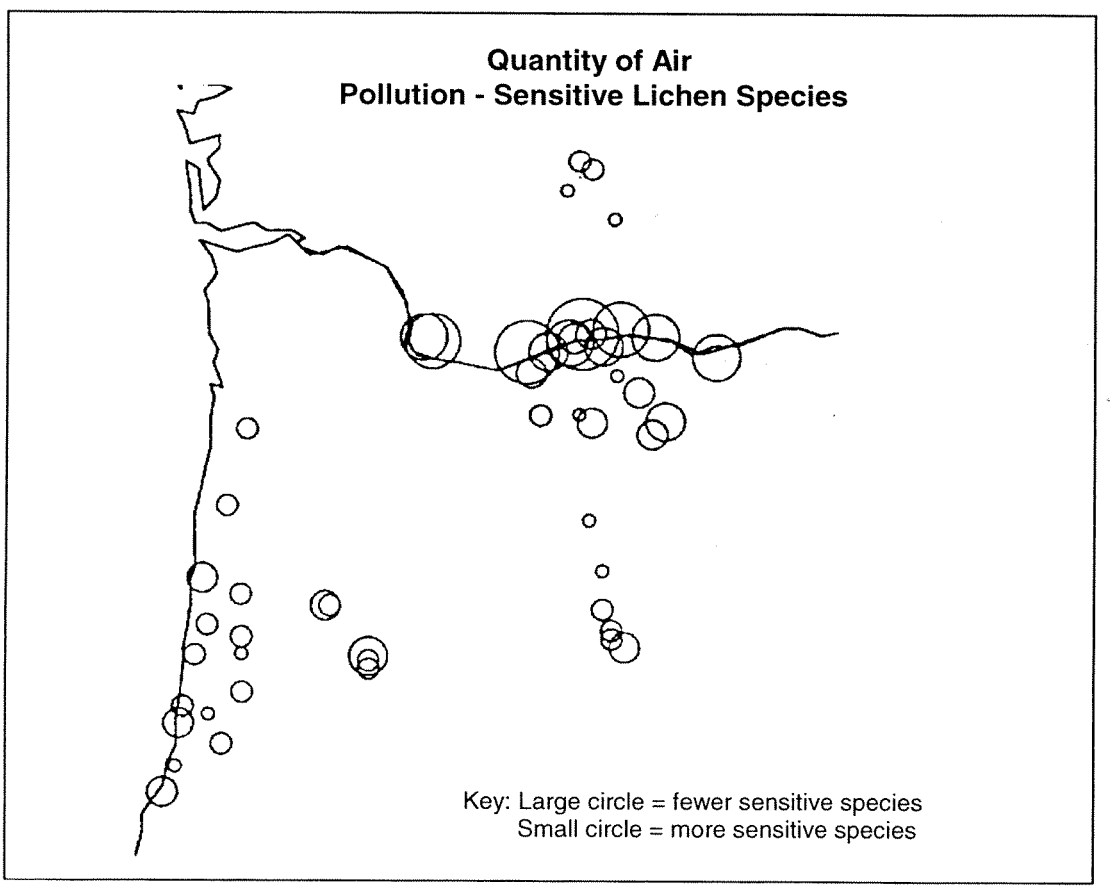


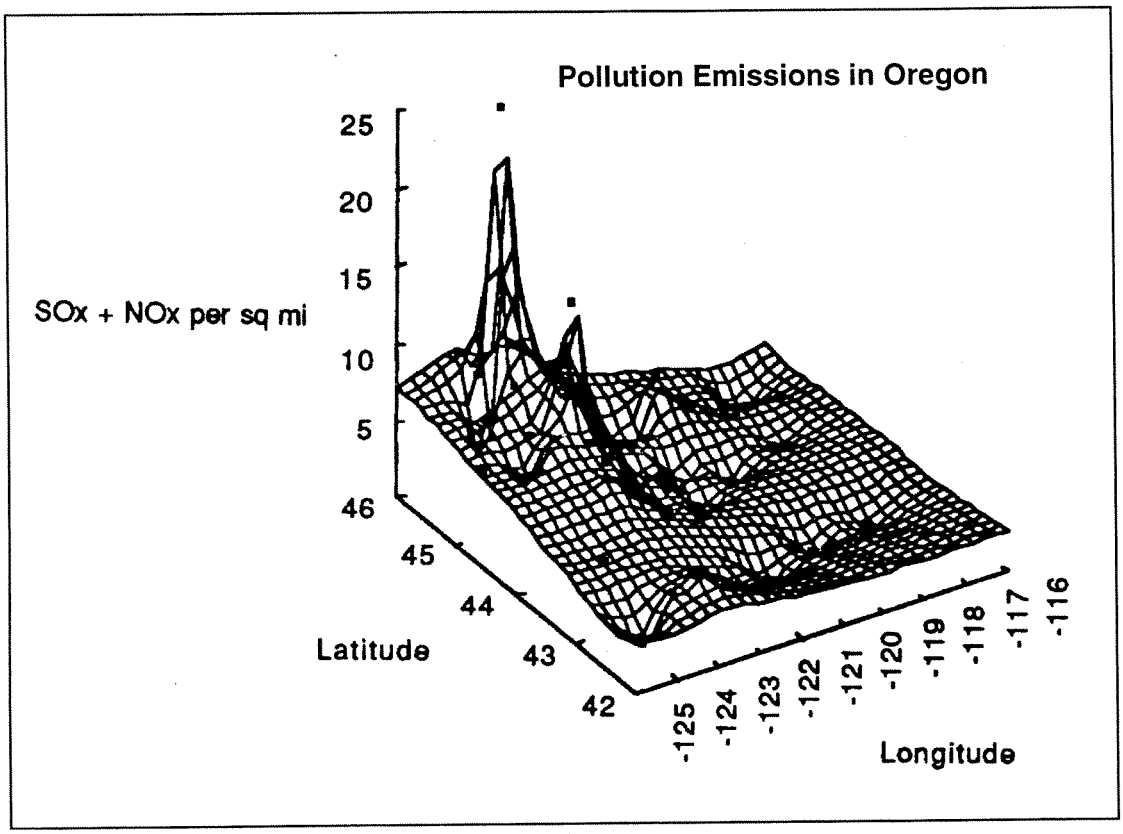
AIR POLLUTION

Air quality monitoring in Oregon and Washington includes looking at air pollution impacts on lichens, monitoring air visibility, and monitoring air pollution deposition in high mountains lakes, as well as other activities (such as monitoring impacts to air quality from wildland fire).

Lichens as Bioindicators. Lichen abundance, species composition and diversity are indicators of the type and amount of air pollution. The Columbia River Gorge National Scenic Area and Deschutes, Gifford-Pinchot, Mt. Hood, Siuslaw and Willamette National Forests have study sites overlaying the Forest Service's Current Vegetation Survey (CVS) plot grid. Lichens on trees and shrubs are surveyed on these sites and samples are collected for tissue analysis. The data will be used to map overall air quality as well as deposition patterns of individual pollutants in these national forests. An abundance of air pollution-sensitive species at a site is good indication of good air quality.

Sites were scored for air quality based on lichen species composition (see map below). A larger circle indicates fewer sensitive species and poorer air quality. Site scores correlate very well with a map (see second map below) of pollution emissions by county (Multnomah county -100 tons of SO2 and NOx/sq. Mi. - was not included so that emission topology in the rest of the State could be seen more clearly).



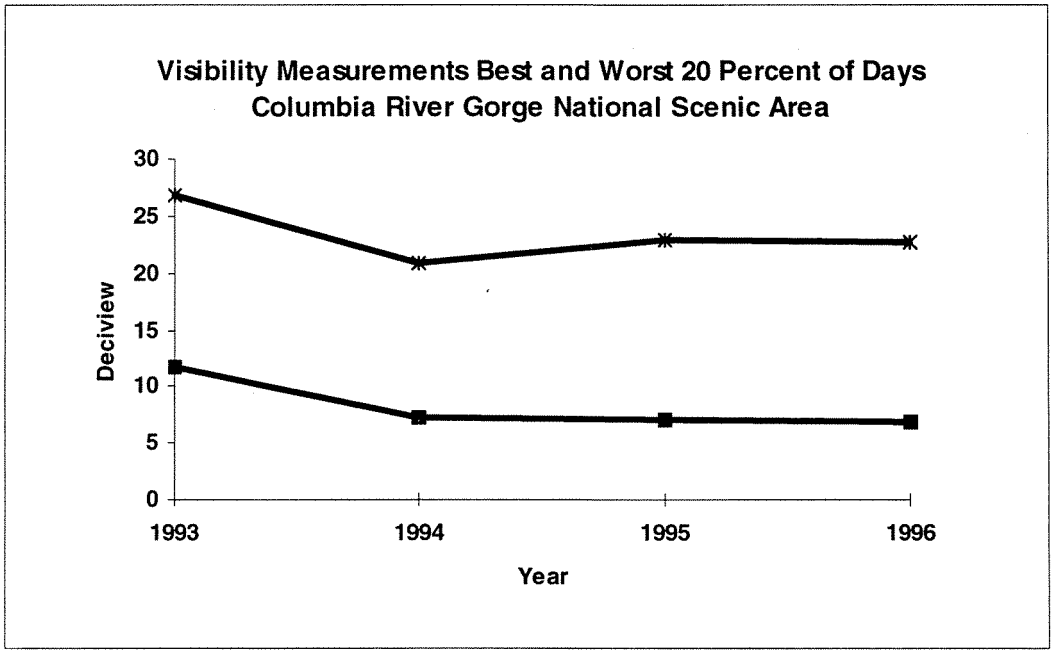


Sulfur content of samples of one lichen, *Hypogymnia enteromorpha*, in the Columbia River Gorge and western Mt. Hood National Forest was up to 300 percent higher than those in surrounding areas, indicating a much higher concentration rate.

The lichen program is closely linked with the national Forest Health Monitoring (FHM) program. Information collected within the Region can be compared to national data to obtain a national perspective of conditions in the Region. Adopting the methods and quality control standards by this national program saved development costs and strengthens the credibility of the regional program.

Air Visibility. Visibility conditions in certain Clean Air Act (CAA) protected (Class I) wilderness, national parks, and wildlife refuges are monitored by a variety of agencies, including the Forest Service, National Park Service, Washington Department of Ecology, and the Puget Sound Air Pollution Control Authority through the IMPROVE program (Interagency Monitoring of Protected Visual Environments). The IMPROVE network in Washington State is the largest of any state in the US. Particulate samplers measure a wide range of the particulate chemical spectrum of fine particles in the atmosphere. These particles scatter or absorb light which are the cause of visibility impairment. The sulfur and nitrogen information is related to acid rain. Tracer chemical species are also monitored so that information can be derived on the sources that emit the pollutants.

The following graph shows data collected from 20 percent of the dirtiest days (top line) and 20 percent of the cleanest days (bottom line). The deciview index expresses uniform changes in haziness from pristine to extremely impaired; a one deciview change in haziness is a small but noticeable change in haziness under most circumstances when viewing scenes in Class 1 areas.



Data collected from this network have been invaluable in determining the extent of visibility conditions in Western Washington and Oregon and the sources responsible. By far the most significant result is the recent agreement to reduce emissions from the Centralia Coal Fired Power Plant which impacts wilderness and park resources in the central Washington Cascades. The Centralia Plant is the largest pollution source in the Western US, emitting 70,000 tons per year of sulfur dioxide and 18,000 tons per year of nitrogen dioxide, both precursor pollutants for visibility impairment and acid rain.

Lake Acidity. Lakes in the Pacific Northwest include some of the most sensitive to acid deposition in the country. A lake's vulnerability to acid deposition is often characterized by a chemical parameter called ANC or acid neutralizing capacity. ANC is important to lakes because it provides them with an ability to buffer acids that may be deposited from air pollution - a sort of immune system. Once ANC approaches or reaches zero, the lake can no longer resist acidification, the pH will begin to change and the lake could quickly become acidified. Lakes with an ANC of less than 200 are considered sensitive and if less than 50 are extremely sensitive. Acidification can cause the lake to be a difficult place for aquatic creatures and fish to live.

Air pollution can end up in a lake by being carried in by rain, snow, or through dry deposition where the tiny pollutant particles fall out of dry air into the lake or its watershed. Pollutants can enter a lake on a chronic or daily basis, or they can enter over a short period of time such as when snow melts. Acidification caused by a flush of pollutants

entering the lake during spring snow melt is called episodic and can only be detected with samples taken early in spring.

The Mt. Baker-Snoqualmie and the Wenatchee National Forests have begun studying lakes in the Cascades, especially those in the Alpine Lakes and Glacier Peaks wilderness areas. We are interested in establishing the baseline chemical condition of lakes, in finding those lakes that are the most sensitive to acidification, and in determining whether any lakes are currently experiencing chronic or episodic acidification.

WEATHER DAMAGE

Winter Weather. The winter of 1995-96 was one of extremes. High winds, long periods of extreme cold, above-average snowpack, and torrential rains combined to set the stage for the worst flooding in 30 years. In mid-January, snowpack in the northwest Cascade range averaged less than 30 percent of the long term average. During the last 2 weeks of January, the snowpack increased at a rate of several feet per day. By the end of January, the average snowpack had climbed to over 100 percent of average. Freezing rain in early February brought the Willamette Valley to a standstill for 3 days. In southern Oregon Cascades (3,500-4,500 feet elevation), heavy wet snow resulted in tree breakage and windthrow.

A "Pineapple Express," a warm, wet weather system, brought a combination of heavy rainfall and warm temperatures to Oregon and Washington in early February. The strong surge of warm rain swept across central and northern Oregon, Washington, and then into Idaho. Average daily air temperatures rose as much as 30 degrees F in a period of 1 to 2 days. Rainfall and temperature returned to normal by February 10. By that time, however, the rain that had fallen and the melted snow from low and mid-elevations, was moving rapidly downstream, causing flooding along rivers that would last for several weeks in some locations.

November 95 --- Unusually heavy rainfall
December 95 --- Hurricane-force winds
January 96 ------ Heavy snowpack
February 96 ---- Freezing rain
February 96 ---- High temperatures and heavy rainfall

Most of the storm damage occurred in four river basins: the Upper Cowlitz, southeast of Olympia., WA; the Clackamas, near Estacada, OR; the South Santiam, above Corvallis, OR; and the Wilson-Trask-Nestucca, near Tillamook on the Oregon coast.

Damage to forests included road and bridge washouts, streambank erosion, channel changes, landslides, and trail damage. Thousands of miles of roads were damaged or destroyed during the floods. Bridges were washed away or undermined enough to be unsafe for public access. The storms of 1996 produced thousands of landslides in the Cascade and Oregon Coast mountain ranges. With few exceptions, the primary ingredients for landslides are steep slopes, water, and weak soils or rocks. Vegetation influences landslides both by binding soil with the roots and by using soil moisture that

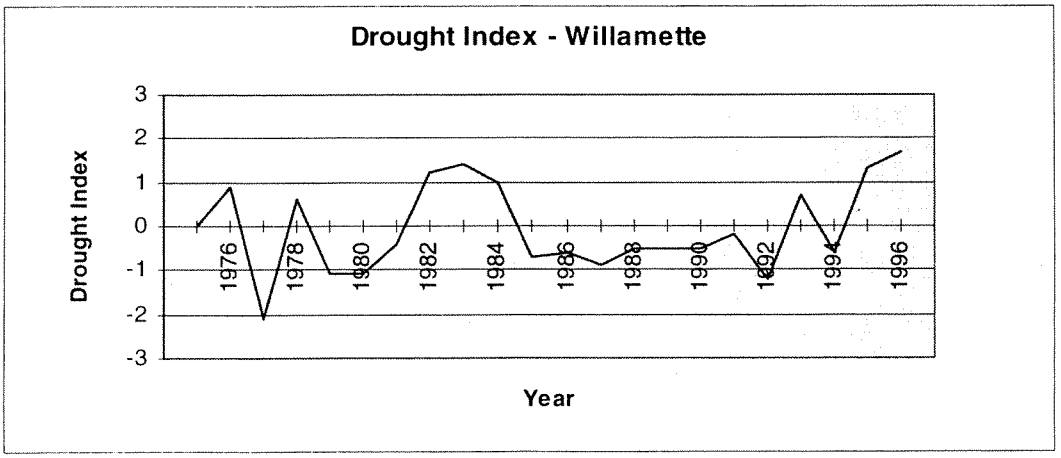
would otherwise tend to saturate the soil profile. Tree harvesting, fire, and roads are thought to increase the frequency of landslides.

Many river systems were affected by the floods; in some systems, stable, well-vegetated slopes and streambanks combined with fully functioning floodplains buffered the effects of the floods. In these systems, overall effects to fish habitat were positive. In other systems, extensive streambank erosion and channel changes were common. Huge quantities of rock, soil, and debris from landslides scoured hundreds of miles of salmon and steelhead spawning and rearing habitat. In some areas, bank failures exposed clay material that moved into and clouded drinking water supplies.

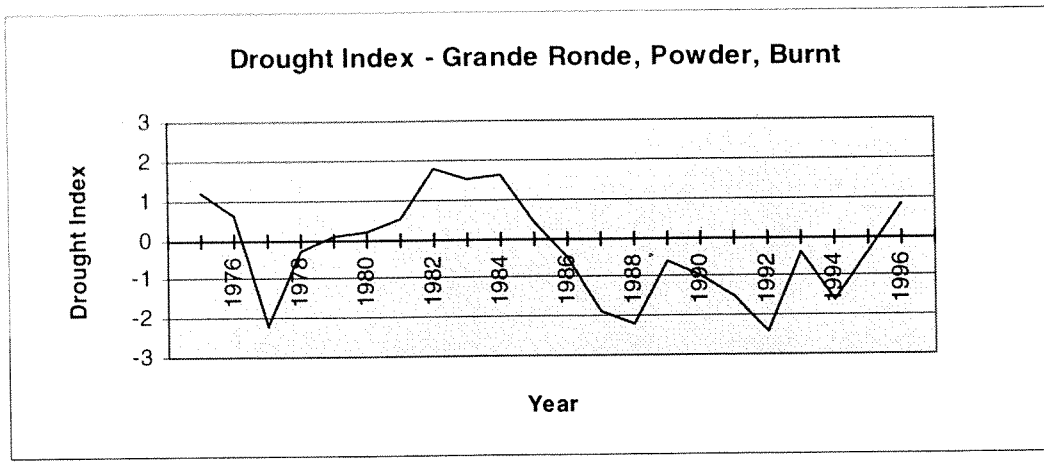
Spring and Summer Weather. Abundant rain fell in late spring (May and June), followed by hot and dry weather in July, August, and September in eastern Washington and throughout Oregon. In western Washington, weather was cool and wet in April and May, cool and cloudy in June, and, in July and August, several timely episodes of wetting rains ended short-lived droughts. Insect-related tree mortality decreased in response to wetter conditions in most locations throughout the Pacific Northwest. Conversely, foliage diseases increased with wetter weather providing more conducive conditions for infection. Even though overall precipitation in Oregon and Washington during 1996 was greater than the 100-year average in most locations, the dry summer weather, coupled with abundant fine fuels (produced by the rain earlier in the season) and frequent thunderstorms with lightning, resulted in numerous forest fires in 1996, particularly in Oregon.

Drought indices for various areas in Oregon consistently were positive (wetter) for 1996. See Appendix 4 for explanation of drought index.

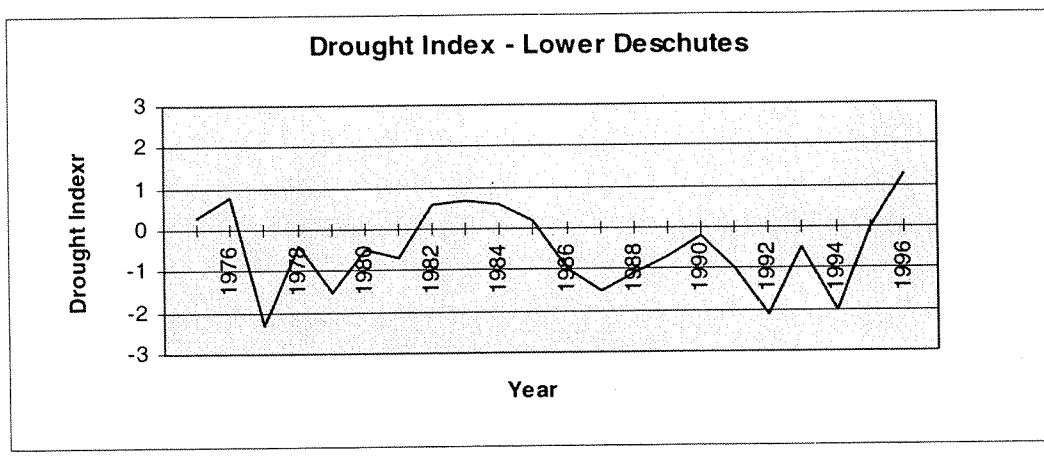
Northwest Oregon:



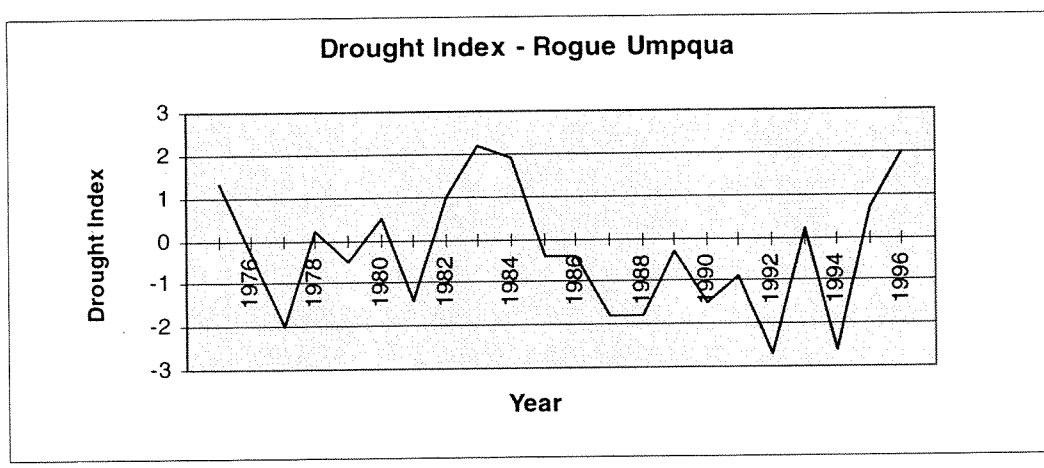
Blue Mountains:



Central Oregon:

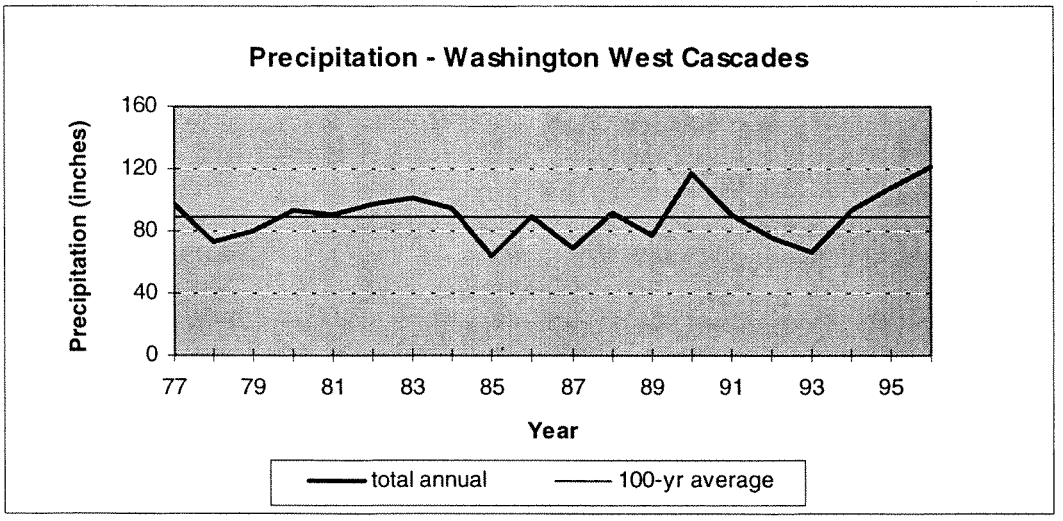


Southwest Oregon:

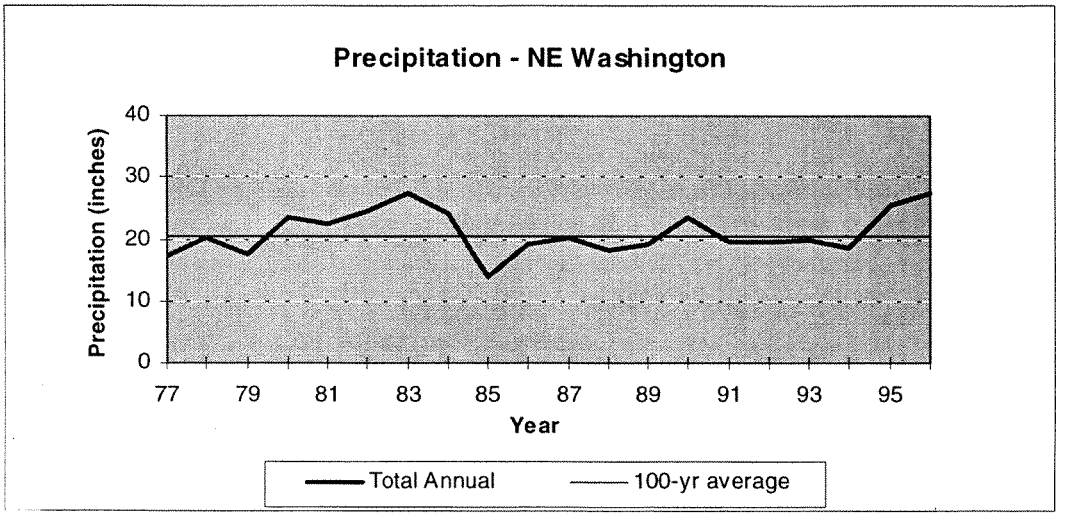


Similarly, annual total precipitation in various areas throughout Washington was greater than the 100-year average in 1996.

Western Washington:



Eastern Washington:



MORTALITY FROM ALL CAUSES

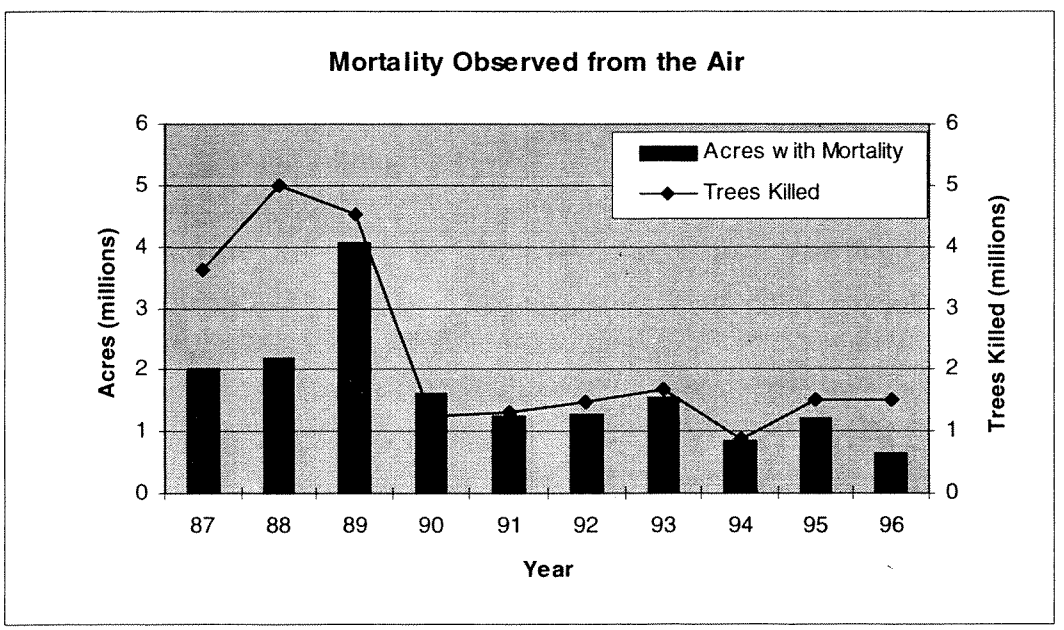
Tree mortality in Oregon and Washington is monitored by aerial surveys and on ground plots. Both are good ways of observing changes in mortality over time, but they are generally not comparable to one another.

Aerial Survey vs Ground Plots
Different Ways of Measuring Mortality

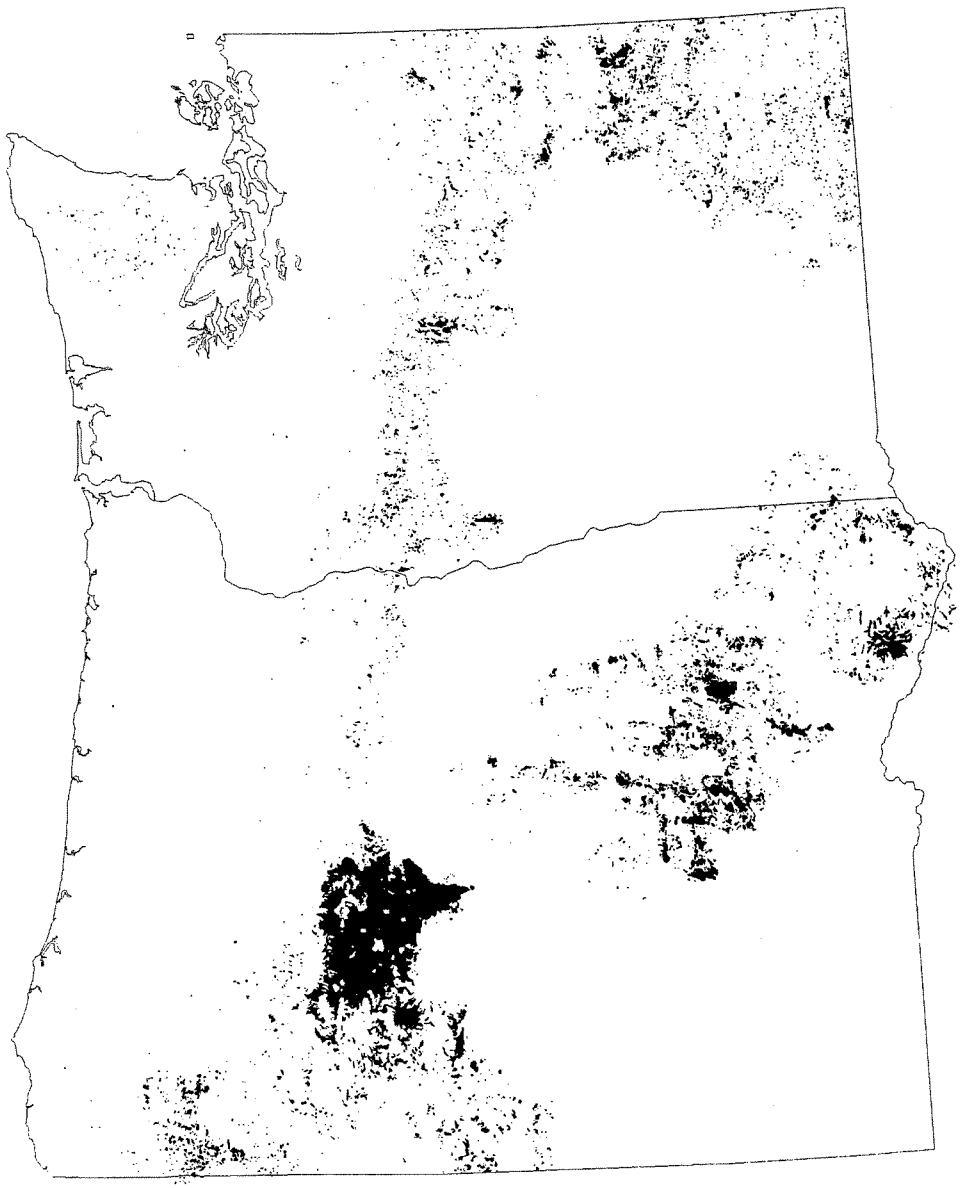
Aerial Survey	Ground Plots
100% Coverage	<100% Sample
Overstory Mortality	Overstory & Understory Mortality
Current Year Mortality	Recent (1-5 years) Mortality
Survey Flown Every Year	Plots Not Measured Every Year

Both are good ways of observing changes in mortality over time.
But they are generally not comparable to one another!

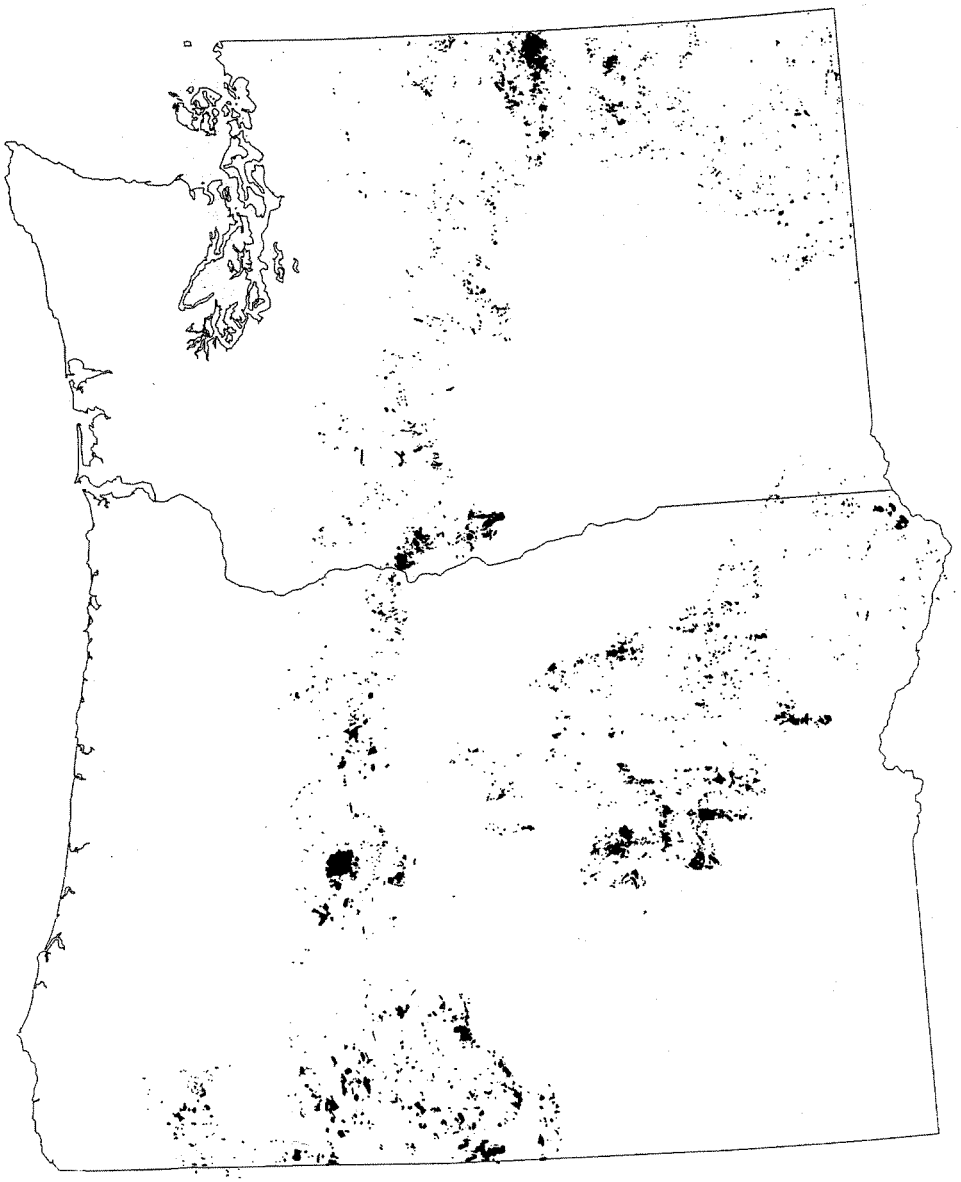
Aerially Observed Mortality. Tree mortality observable from the air in Oregon and Washington increased slightly in 1996. Data from the insect and disease aerial surveys show about a 1 percent increase in the number of trees killed from 1995 but a 47 percent decrease in the number of acres with some level of mortality (dead trees per acre increased from 1.2 trees per acre in 1995 to 2.4 trees per acre in 1996). Cumulative acres with mortality between 1992 and 1996 decreased significantly from the previous 5 year period, 1987 to 1991. Much of this change is thought to be due to increased rainfall over the past few years, with a subsequent reduction in drought stress and susceptibility to bark beetles and other mortality agents.



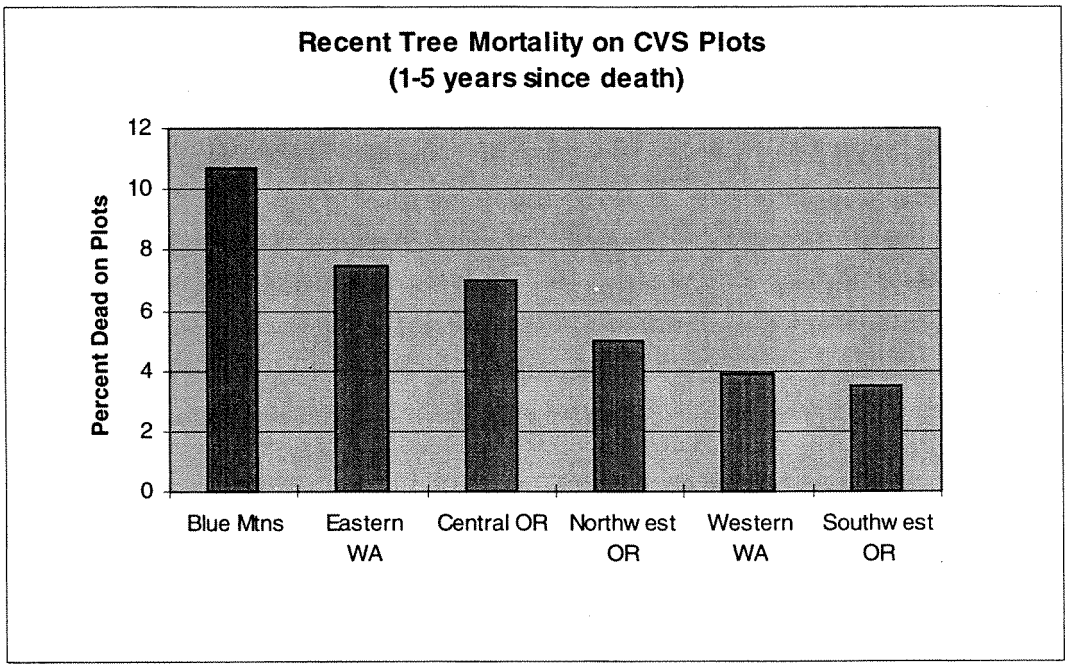
Cumulative Mortality 1987-1991



Cumulative Mortality 1992-1996



Ground Observed Mortality. Tree mortality is also measured on the CVS plots. Data collected in 1993 and 1994 show the following incidence of mortality on national forest plots.



REFERENCES

Campbell, Sally; Liegel, Leon, tech coords. 1996. **Disturbance and Forest Health in Oregon and Washington**. Gen. Tech. Rep. PNW-GTR-381. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Pacific Northwest Region, Oregon Department of Forestry; Washington Department of Natural Resources. 105 p.

McCammon, Bruce. 1997. **Flooding in the Pacific Northwest**. Briefing Paper. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 4 p.

Oregon Department of Forestry, Forest Health Program. 1996. **Swiss Needle Cast of Douglas-fir in Coastal Western Oregon**. Forest Health Note. Oct. 1996. Salem, OR: Oregon Department of Forestry. 6 p.

Overholser, Dave; McWilliams, Mike. 1996. **Results of the 1996 Western Oregon Tree Mortality Survey**. Forest Health Rep. No. 96-1. Salem, OR: Oregon Department of Forestry. 8 p.

Sprengel, Keith, comp. 1995. **Forest Insect and Disease Conditions, Pacific Northwest Region, 1994**. R6-FID-TP-06-95. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 64 p.

USDA, Forest Service. 1996. **Northwest Area Annual Fire Report, 1996**. Interagency Report. Portland, OR: U.S. Department of Agriculture, Forest Service; U.S. Department of Interior, Bureau of Land Management, Bureau of Indian Affairs, Fish and Wildlife Service, and National Park Service; Oregon Department of Forestry; Washington Department of Natural Resources. 44 p.

USDA, Forest Service. 1997. **Region 6 Inventory and Monitoring System: Field Procedures for the Current Vegetation Survey. Version 2.01** Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Natural Resource Inventory. xx p.

APPENDICES

APPENDIX 1
Aerial Survey Methods

AERIAL SURVEY IN OREGON AND WASHINGTON

Aerial survey data included in this report are based on sketchmaps prepared by observers during aerial survey flights. The cooperative aerial survey begins in early July and usually ends in September, depending on weather and visibility conditions. The survey is timed to observe the maximum amount of damage in a 2- to 3-month period. However, not all damage can be observed or recorded within one flight period (some insects or diseases cause symptoms that are visible earlier or later in the year). Special flights are sometimes made to detect damage that is most visible outside the usual flight period, such as the Oregon Department of Forestry special surveys for Swiss needle cast and bear damage in the spring.

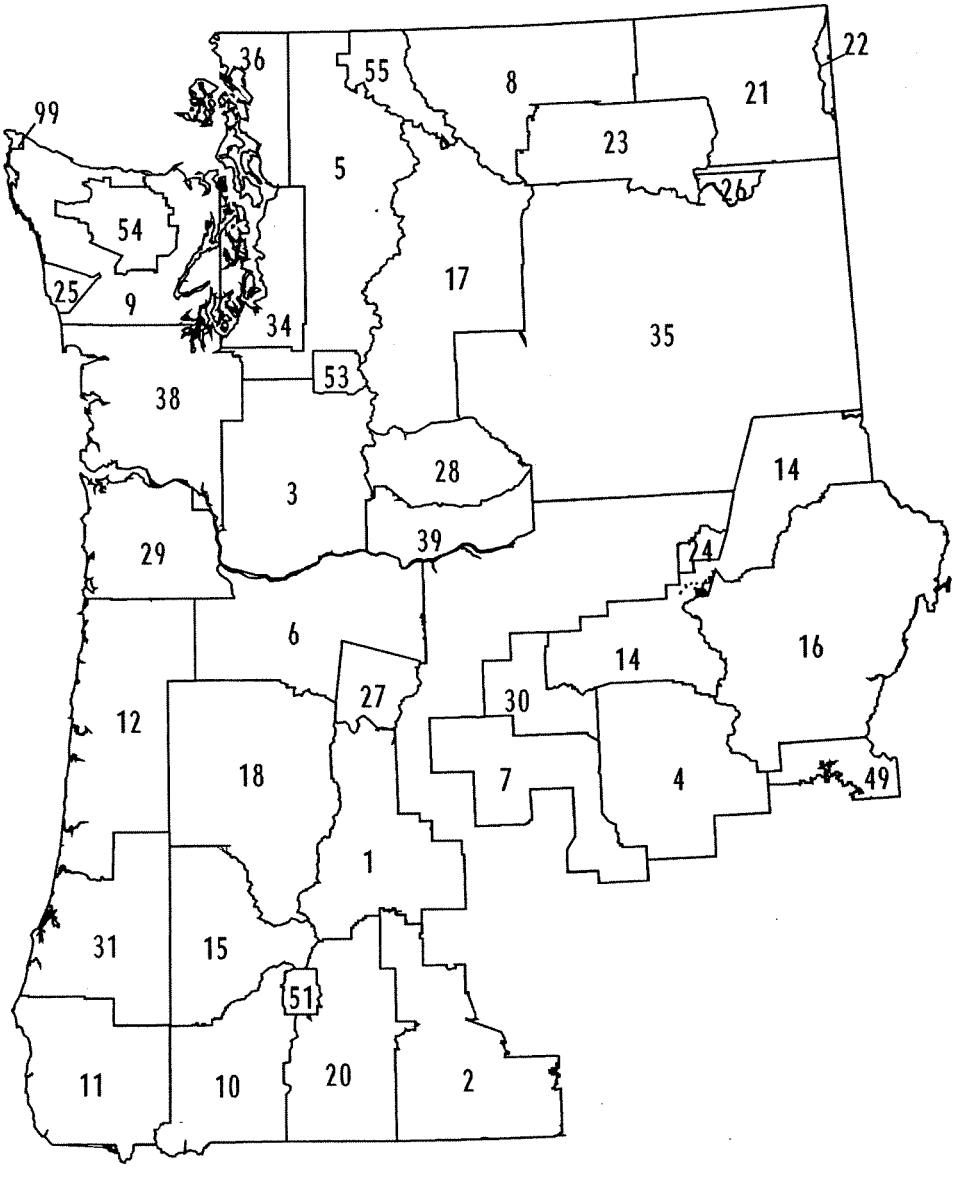
Aerial survey observers have just a few seconds to recognize color differences between healthy and damaged trees of different species; diagnose the cause of damage correctly; estimate the intensity or extent of damage; and record observations as accurately as possible on a 1:100,000 scale map. Numerous variables can affect the quality of the survey from which the bulk of the enclosed data is derived. These include visual quality (poor visiblity can be caused by wildfire smoke, low sun angle, clouds, haze); similar damage symptoms in different hosts; and observer skill and training. In spite of these limitations, aerial sketchmapping surveys are a cost-effective way to rapidly estimate tree damage (especially caused by insects) across large areas.

Although aerial data may differ from ground-based data, it provides an estimate of the current status of tree health over all ownerships throughout the two states; this coverage and frequency is usually not possible with ground plots or ground observations. Annual aerial survey data also is important in examining insect and disease activity trends over several years, especially since Oregon and Washington have over 30 years of aerial survey data.

Aerial survey information, specific to your area, can be requested from the Forest Disease and Insect Group in the Forest Service Regional Office (503-808-2995).

APPENDIX 2
Aerial Survey
Reporting Areas

Aerial Survey Reporting Areas



Reporting Area Key

1 Deschutes National Forest
2 Fremont National Forest
3 Gifford Pinchot National Forest
4 Mt. Baker-Snoqualmie National Forest
5 Mt Hood National Forest
6 Ochoco National Forest
8 Okanogan National Forest
9 Olympic National Forest
10 Rogue River National Forest
11 Siskiyou National Forest
12 Siuslaw National Forest
14 Umatilla National Forest
15 Umpqua National Forest
16 Wallowa-Whitman National Forest
17 Wenatchee National Forest
18 Willamette National Forest
20 Winema National Forest
21 Colville National Forest
22 Kaniksu National Forest
23 Colville Indian Reservation
24 Umatilla Indian Reservation
25 Quinalt Indian Reservation
26 Spokane Indian Reservation
27 Warm Springs Indian Reservation
28 Yakama Indian Reservation
29 Northwest Oregon
30 Central Oregon
31 Coos-Douglas
34 Puget Sound
35 Northeast Washington
36 Northwest Washington
38 Southeast Washington
39 Glenwood
49 Lookout Mountain
51 Crater Lake National Park
53 Mt Rainier National Park
54 Olympic National Park
55 North Cascades National Park
99 Makah Indian Reservation

APPENDIX 3
Aerial Survey
Summary Tables

Table 1. Damaging agent, acres, trees, and volume

Year	Damaging Agent	Acres Affected	Trees Killed	Million Bd Ft	Million Cu Ft
96	Area not flown	1,511,178.00	0.00	0.00	0.00
96	Balsam woolly adelgid	13,731.00	16,203.00	0.00	0.00
96	Bear	29,497.00	39,112.00	0.00	0.00
96	Blister rust	4,707.00	0.00	0.00	0.00
96	Cytospora canker	42.00	0.00	0.00	0.00
96	Douglas-fir beetle	9,661.00	7,739.00	5,222.33	1,142.93
96	Douglas-fir beetle engraver	71.00	73.00	4.38	0.95
96	Dying hemlock	1,702.00	0.00	0.00	0.00
96	Engelmann spruce beetle	9,659.00	31,860.00	7,961.00	1,648.33
96	Fir engraver	377,605.00	812,915.00	318,360.27	63,127.74
96	Fire	675.00	0.00	0.00	0.00
96	Flatheaded woodborer	58.00	92.00	14.20	3.13
96	Lodgepole pine needle cast	3,139.00	0.00	0.00	0.00
96	Mountain pine beetle, Jeffrey pine	4.00	18.00	1.08	0.22
96	Mountain pine beetle, lodgepole pine	152,465.00	571,886.00	40,022.43	8,318.25
96	Mountain pine beetle, ponderosa pine	5,910.00	7,747.00	415.62	82.25
96	Mountain pine beetle, sugar pine	550.00	251.00	239.84	52.93
96	Mountain pine beetle, w. white pine	8,361.00	5,855.00	2,759.06	559.60
96	Mountain pine beetle, whitebark pine	2,962.00	997.00	45.89	8.90
96	Oregon pine ips	925.00	872.00	0.00	0.00
96	Pacific Madrone decline	1,572.00	0.00	0.00	0.00
96	Pandora moth	12,258.00	0.00	0.00	0.00
96	Pine needle scale	9.00	0.00	0.00	0.00
96	Port Orford cedar root disease	2,609.00	1,872.00	0.00	0.00
96	Red belt	221.00	0.00	0.00	0.00
96	Root disease	2,870.00	0.00	0.00	0.00
96	Satin moth	196.00	0.00	0.00	0.00
96	Silver fir beetle	863.00	628.00	315.69	72.25
96	Slide	1,382.00	0.00	0.00	0.00
96	Spruce aphid	214.00	0.00	0.00	0.00
96	Tent caterpillar	842.00	0.00	0.00	0.00
96	Water	1,308.00	0.00	0.00	0.00
96	Western balsam bark beetle	4,434.00	3,755.00	0.00	0.00
96	Western hemlock looper	1,542.00	0.00	0.00	0.00
96	Western oak looper	21.00	0.00	0.00	0.00
96	Western pine beetle	18,596.00	13,682.00	10,011.49	2,065.19
96	Western pine beetle, small trees	11,157.00	12,456.00	2,450.75	498.56
96	Western spruce budworm	190,784.00	0.00	0.00	0.00
96	Wind	860.00	0.00	0.00	0.00
96	Winter damage	320.00	0.00	0.00	0.00
	Totals	***2,384,960.00***	***1,528,013.00***	***387,824.03***	***77,581.23***

Table 2. Land Status, State, Reporting Area, Damage Type, Acres, and Trees

Land Status	State	Reporting Area	Acres Defoliation	Acres Mortality	Trees Killed	Acres Other Damage	Trees Killed Other Damage	Acres Not Flown
Forest Service	Oregon	Deschutes	9,096.00	55,266.00	198,761.00	0.00	0.00	0.00
Forest Service	Oregon	Fremont	4,067.00	194,051.00	526,672.00	0.00	0.00	0.00
Forest Service	Oregon	Malheur	0.00	10,045.00	8,571.00	0.00	0.00	71,410.00
Forest Service	Oregon	Mt. Hood	568.00	1,375.00	405.00	933.00	103.00	0.00
Forest Service	Oregon	Ochoco	0.00	2,709.00	3,904.00	95.00	24.00	0.00
Forest Service	Oregon	Rogue River	0.00	3,076.00	3,260.00	0.00	0.00	0.00
Forest Service	Oregon	Siskiyou	0.00	330.00	207.00	1.00	5.00	0.00
Forest Service	Oregon	Siuslaw	0.00	42.00	78.00	122.00	0.00	0.00
Forest Service	Oregon	Umatilla	0.00	1,631.00	1,838.00	0.00	0.00	158,100.00
Forest Service	Oregon	Umpqua	0.00	810.00	263.00	58.00	0.00	0.00
Forest Service	Oregon	Wallowa-Whitman	0.00	4,833.00	5,366.00	0.00	0.00	146,360.00
Forest Service	Oregon	Willamette	60.00	4,398.00	1,362.00	512.00	58.00	0.00
Forest Service	Oregon	Winema	0.00	78,912.00	158,931.00	0.00	0.00	0.00
	OR subtotal		*13,791.00*	*357,478.00*	*909,618.00*	*1,721.00*	*190.00*	*375,870.00*
Forest Service	Washington	Colville	178.00	4,209.00	3,588.00	58.00	20.00	0.00
Forest Service	Washington	Gifford-Pinchot	6,949.00	4,582.00	4,229.00	1,354.00	172.00	0.00
Forest Service	Washington	Kaniksu	53.00	1,275.00	563.00	0.00	0.00	0.00
Forest Service	Washington	Mt. Baker-Snoqualmie	1,113.00	2,865.00	2,270.00	2,123.00	647.00	0.00
Forest Service	Washington	Okanogan	90.00	21,844.00	60,572.00	402.00	0.00	0.00
Forest Service	Washington	Olympic	0.00	586.00	2,187.00	171.00	75.00	0.00
Forest Service	Washington	Umatilla	0.00	179.00	222.00	0.00	0.00	0.00
Forest Service	Washington	Wenatchee	115.00	10,269.00	13,449.00	970.00	324.00	0.00
	WA subtotal		*8,498.00*	*45,809.00*	*87,080.00*	*5,078.00*	*1,238.00*	*0.00*
Forest Service	***Grand Total***		***22,289.00***	***403,287.00***	***996,698.00***	***6,799.00***	***1,428.00***	***375,870.00***

Land Status	State	Reporting Area	Acres Defoliation	Acres Mortality	Trees Killed	Acres Other Damage	Trees Killed Other Damage	Acres Not Flown
State	Oregon	Coos-Douglas	0.00	8.00	8.00	2.00	0.00	0.00
State	Oregon	Fremont	0.00	2,523.00	9,650.00	0.00	0.00	0.00
State	Oregon	Mt. Hood	0.00	9.00	10.00	0.00	0.00	0.00
State	Oregon	Northwest Oregon	0.00	336.00	429.00	1,000.00	0.00	0.00
State	Oregon	Ochoco	0.00	7.00	3.00	0.00	0.00	0.00
State	Oregon	Rogue River	0.00	18.00	15.00	0.00	0.00	0.00
State	Oregon	Siskiyou	0.00	11.00	3.00	0.00	0.00	0.00
State	Oregon	Siuslaw	0.00	15.00	28.00	66.00	0.00	0.00
State	Oregon	Winema	0.00	11.00	10.00	0.00	0.00	0.00
	OR subtotal		*0.00*	*2,938.00*	*10,156.00*	*1,068.00*	*0.00*	*0.00*
State	Washington	Colville	1,904.00	457.00	453.00	0.00	0.00	0.00
State	Washington	Colville IR	84.00	380.00	353.00	0.00	0.00	0.00
State	Washington	Gifford-Pinchot	5.00	620.00	804.00	69.00	5.00	0.00
State	Washington	Glenwood	1,938.00	107.00	104.00	17.00	10.00	2,454.00
State	Washington	Mt. Baker-Snoqualmie	0.00	1,546.00	1,226.00	39.00	0.00	1,708.00
State	Washington	Northeast WA	0.00	640.00	590.00	0.00	0.00	0.00
State	Washington	Northwest WA	0.00	352.00	275.00	685.00	0.00	3,136.00
State	Washington	Okanogan	0.00	13,212.00	39,623.00	0.00	0.00	0.00
State	Washington	Olympic	0.00	1,617.00	1,652.00	198.00	0.00	0.00
State	Washington	Puget Sound	0.00	37.00	35.00	6.00	0.00	3,926.00
State	Washington	Southwest WA	0.00	464.00	395.00	12.00	0.00	1,539.00
State	Washington	Umatilla	0.00	1.00	0.00	0.00	0.00	0.00
State	Washington	Wenatchee	8.00	1,532.00	1,762.00	427.00	0.00	0.00
	WA subtotal		*3,939.00*	*20,965.00*	*47,272.00*	*1,453.00*	*15.00*	*12,763.00*
States	***Grand Total***		***3,939.00***	***23,903.00***	***57,428.00***	***2,521.00***	***15.00***	***12,763.00***

Land Status	State	Reporting Area	Acres Defoliation	Acres Mortality	Trees Killed	Acres Other Damage	Trees Killed Other Damage	Acres Not Flown
Private	Oregon	Central Oregon	0.00	1,703.00	4,392.00	0.00	0.00	0.00
Private	Oregon	Coos-Douglas	0.00	1,361.00	1,296.00	28.00	0.00	0.00
Private	Oregon	Deschutes	1,317.00	1,852.00	1,990.00	0.00	0.00	0.00
Private	Oregon	Fremont	2,568.00	48,012.00	121,000.00	0.00	0.00	0.00
Private	Oregon	Malheur	0.00	869.00	759.00	0.00	0.00	58,273.00
Private	Oregon	Mt. Hood	64.00	176.00	120.00	469.00	30.00	0.00
Private	Oregon	Northwest Oregon	0.00	540.00	585.00	433.00	0.00	0.00
Private	Oregon	Ochoco	0.00	1,099.00	1,469.00	0.00	0.00	0.00
Private	Oregon	Rogue River	0.00	1,521.00	1,281.00	2.00	0.00	0.00
Private	Oregon	Siskiyou	0.00	1,827.00	1,219.00	5.00	5.00	0.00
Private	Oregon	Siuslaw	21.00	164.00	283.00	125.00	0.00	0.00
Private	Oregon	Umatilla	0.00	766.00	613.00	0.00	0.00	28,809.00
Private	Oregon	Umatilla IR	0.00	30.00	34.00	0.00	0.00	0.00
Private	Oregon	Umpqua	0.00	60.00	37.00	13.00	0.00	0.00
Private	Oregon	Wallowa-Whitman	356.00	769.00	552.00	0.00	0.00	3,860.00
Private	Oregon	Willamette	0.00	162.00	113.00	226.00	0.00	0.00
Private	Oregon	Winema	0.00	20,516.00	25,501.00	0.00	0.00	0.00
	subtotal		*4,326.00*	*81,427.00*	*161,244.00*	*1,301.00*	*35.00*	*85,942.00*
Private	Washington	Colville	2,817.00	2,700.00	2,320.00	22.00	10.00	0.00
Private	Washington	Colville IR	88.00	930.00	810.00	6.00	0.00	0.00
Private	Washington	Gifford-Pinchot	209.00	4,093.00	3,679.00	220.00	61.00	0.00
Private	Washington	Glenwood	15,642.00	842.00	760.00	0.00	0.00	54,520.00
Private	Washington	Mt. Baker-Snoqualmie	50.00	5,719.00	6,252.00	286.00	31.00	46,694.00
Private	Washington	Northeast WA	4.00	1,825.00	1,654.00	0.00	0.00	0.00
Private	Washington	Northwest WA	0.00	570.00	393.00	189.00	0.00	81,275.00
Private	Washington	Okanogan	170.00	457.00	740.00	0.00	0.00	0.00
Private	Washington	Olympic	0.00	1,690.00	1,153.00	356.00	0.00	0.00
Private	Washington	Puget Sound	0.00	2,213.00	9,913.00	393.00	0.00	463,388.00

Land Status	State	Reporting Area	Acres Defoliation	Acres Mortality	Trees Killed	Acres Other Damage	Trees Killed Other Damage	Acres Not Flown
Private	Washington	Southwest WA	0.00	3,067.00	2,975.00	163.00	0.00	25,092.00
Private	Washington	Spokane IR	0.00	99.00	50.00	0.00	0.00	0.00
Private	Washington	Umatilla	0.00	62.00	48.00	0.00	0.00	0.00
Private	Washington	Wenatchee	174.00	5,252.00	5,707.00	757.00	46.00	0.00
Private	Washington	Yakima IR	13,272.00	12.00	6.00	0.00	0.00	0.00
	subtotal		*32,426.00*	*29,553.00*	*36,468.00*	*2,602.00*	*148.00*	*673,818.00*
Private	***Grand total***		***36,752.00***	***110,980.00***	***197,712.00***	***3,903.00***	***183.00***	***759,760.00***

Land Status	State	Reporting Area	Acres Defoliation	Acres Mortality	Trees Killed	Acres Other Damage	Trees Killed Other Damage	Acres Not Flown
BLM	Oregon	Central Oregon	0.00	48.00	114.00	0.00	0.00	0.00
BLM	Oregon	Coos-Douglas	0.00	82.00	125.00	15.00	0.00	0.00
BLM	Oregon	Deschutes	1,845.00	109.00	72.00	0.00	0.00	0.00
BLM	Oregon	Fremont	0.00	2,409.00	17,575.00	0.00	0.00	0.00
BLM	Oregon	Malheur	0.00	36.00	32.00	0.00	0.00	3,243.00
BLM	Oregon	Mt. Hood	0.00	1.00	0.00	0.00	0.00	0.00
BLM	Oregon	Northwest Oregon	0.00	3.00	8.00	21.00	0.00	0.00
BLM	Oregon	Ochoco	0.00	88.00	71.00	0.00	0.00	0.00
BLM	Oregon	Rogue River	0.00	2,006.00	1,352.00	8.00	0.00	0.00
BLM	Oregon	Siskiyou	0.00	215.00	120.00	291.00	5.00	0.00
BLM	Oregon	Siuslaw	0.00	181.00	278.00	99.00	0.00	0.00
BLM	Oregon	Umatilla	0.00	14.00	20.00	0.00	0.00	63.00
BLM	Oregon	Umpqua	0.00	38.00	30.00	10.00	0.00	0.00
BLM	Oregon	Wallowa-Whitman	63.00	81.00	49.00	0.00	0.00	0.00
BLM	Oregon	Willamette	0.00	5.00	5.00	10.00	0.00	0.00
BLM	Oregon	Winema	0.00	10,176.00	7,928.00	0.00	0.00	0.00
	subtotal		*1,908.00*	*15,492.00*	*27,779.00*	*454.00*	*5.00*	*3,306.00*
BLM	Washington	Colville	26.00	70.00	66.00	0.00	0.00	0.00
BLM	Washington	Colville IR	0.00	12.00	9.00	0.00	0.00	0.00

Land Status	State	Reporting Area	Acres Defoliation	Acres Mortality	Trees Killed	Acres Other Damage	Trees Killed Other Damage	Acres Not Flown
BLM	Washington	Glenwood	0.00	13.00	16.00	0.00	0.00	3,110.00
BLM	Washington	Northeast WA	0.00	33.00	21.00	0.00	0.00	0.00
BLM	Washington	Okanogan	4.00	71.00	65.00	0.00	0.00	0.00
BLM	Washington	Wenatchee	0.00	98.00	108.00	0.00	0.00	0.00
	subtotal		*30.00*	*297.00*	*285.00*	*0.00*	*0.00*	*3,110.00*
BLM	***Grand Total***		***1,938.00***	***15,789.00***	***28,064.00***	***454.00***	***5.00***	***6,416.00***

Land Status	State	Reporting Area	Acres Defoliation	Acres Mortality	Trees Killed	Acres Other Damage	Trees Killed Other Damage	Acres Not Flown
NPS	Oregon	Crater Lake N.P.	0	141	75	0	0	0
	subtotal		*0*	*141*	*75*	*0*	*0*	*0*
NPS	Washington	Mt. Rainier N.P.	0	183	330	5066	10557	0
NPS	Washington	North Cascades N.P.	2404	2006	2366	412	140	0
NPS	Washington	Olympic N.P.	231	1138	634	1906	1955	0
	subtotal		*2635*	*3327*	*3330*	*7384*	*12652*	*0*
NPS	***Grand Total***		***2635***	***3468***	***3405***	***7384***	***12652***	***0***

Land status	State	Reporting Area	Acres Defoliation	Acres Mortality	Trees Killed	Acres Other Damage	Trees Killed Other Damage	Acres Not Flown
BIA	Oregon	Warm Springs IR	0.00	5,990.00	20,007.00	0.00	0.00	0.00
	subtotal		*0.00*	*5,990.00*	*20,007.00*	*0.00*	*0.00*	*0.00*
BIA	Washington	Colville IR	11.00	4,621.00	3,805.00	0.00	0.00	0.00
BIA	Washington	Northwest WA	0.00	0.00	0.00	0.00	0.00	104.00
BIA	Washington	Puget Sound	0.00	0.00	0.00	0.00	0.00	20,359.00
BIA	Washington	Quinalt IR	228.00	598.00	295.00	12.00	0.00	0.00
BIA	Washington	Spokane IR	0.00	583.00	625.00	0.00	0.00	0.00
BIA	Washington	Yakima IR	140,326.00	3,533.00	3,288.00	374.00	50.00	0.00
	subtotal		*140,565.00*	*9,335.00*	*8,013.00*	*386.00*	*50.00*	*20,463.00*
BIA	***Grand Total***		***140,565.00***	***15,325.00***	***28,020.00***	***386.00***	***50.00***	***20,463.00***

Land Status	State	Reporting Area	Acres Defoliation	Acres Mortality	Trees Killed	Acres Other Damage	Trees Killed Other Damage	Acres Not Flown
Other federal	Oregon	Rogue River	0.00	168.00	92.00	0.00	0.00	0.00
Other federal	Oregon	Winema	0.00	27.00	136.00	0.00	0.00	0.00
	subtotal		*0.00*	*195.00*	*228.00*	*0.00*	*0.00*	*0.00*
Other federal	Washington	Colville	0.00	327.00	297.00	17.00	0.00	0.00
Other federal	Washington	Colville IR	0.00	5.00	5.00	0.00	0.00	0.00
Other federal	Washington	Glenwood	0.00	5.00	0.00	0.00	0.00	0.00
Other federal	Washington	Mt. Baker-Snoqualmie	0.00	56.00	49.00	18.00	0.00	17,556.00
Other federal	Washington	Northeast WA	0.00	10.00	16.00	0.00	0.00	60,522.00
Other federal	Washington	Olympic	0.00	16.00	4.00	0.00	0.00	0.00
Other federal	Washington	Puget Sound	0.00	100.00	799.00	0.00	0.00	0.00
Other federal	Washington	Southwest WA	0.00	0.00	0.00	0.00	0.00	16,728.00
	subtotal		*0.00*	*519.00*	*1,170.00*	*35.00*	*0.00*	*94,806.00*
Other federal	***Grand Total***		***0.00***	***714.00***	***1,398.00***	***35.00***	***0.00***	***94,806.00***

Land Status	State	Reporting Area	Acres Defoliation	Acres Mortality	Trees Killed	Acres Other Damage	Trees Killed Other Damage	Acres Not Flown
Dedicated	Oregon	Deschutes	0.00	21,100.00	112,576.00	0.00	0.00	0.00
Dedicated	Oregon	Fremont	0.00	3,033.00	1,864.00	0.00	0.00	0.00
Dedicated	Oregon	Malheur	0.00	11.00	15.00	0.00	0.00	50,181.00
Dedicated	Oregon	Mt. Hood	226.00	605.00	217.00	534.00	130.00	0.00
Dedicated	Oregon	Ochoco	0.00	73.00	51.00	0.00	0.00	0.00
Dedicated	Oregon	Rogue River	0.00	1,715.00	631.00	0.00	0.00	0.00
Dedicated	Oregon	Siskiyou	0.00	34.00	33.00	34.00	0.00	0.00
Dedicated	Oregon	Umatilla	0.00	136.00	99.00	0.00	0.00	99,492.00
Dedicated	Oregon	Umpqua	0.00	2.00	5.00	0.00	0.00	0.00
Dedicated	Oregon	Wallowa-Whitman	0.00	2,372.00	1,453.00	4.00	5.00	82,995.00
Dedicated	Oregon	Willamette	27.00	2,487.00	597.00	524.00	205.00	0.00
Dedicated	Oregon	Winema	0.00	12,532.00	17,786.00	0.00	0.00	0.00
	subtotal		*253.00*	*44,100.00*	*135,327.00*	*1,096.00*	*340.00*	*232,668.00*

Land Status	State	Reporting Area	Acres Defoliation	Acres Mortality	Trees Killed	Acres Other Damage	Trees Killed Other Damage	Acres Not Flown
Dedicated	Washington	Colville	0.00	166.00	121.00	0.00	0.00	0.00
Dedicated	Washington	Gifford-Pinchot	0.00	171.00	133.00	1,083.00	338.00	0.00
Dedicated	Washington	Kaniksu	0.00	10.00	15.00	0.00	0.00	0.00
Dedicated	Washington	Mt. Baker-Snoqualmie	148.00	314.00	296.00	1,034.00	556.00	0.00
Dedicated	Washington	North Cascades N.P.	0.00	6.00	2.00	0.00	0.00	0.00
Dedicated	Washington	Okanogan	67.00	16,651.00	61,021.00	684.00	0.00	0.00
Dedicated	Washington	Olympic	0.00	65.00	56.00	150.00	155.00	0.00
Dedicated	Washington	Umatilla	0.00	187.00	90.00	0.00	0.00	0.00
Dedicated	Washington	Wenatchee	106.00	2,163.00	1,960.00	1,618.00	554.00	0.00
Dedicated	Washington	Yakima IR	313.00	0.00	0.00	331.00	0.00	0.00
	subtotal		*634.00*	*19,733.00*	*63,685.00*	*4,900.00*	*1,603.00*	*0.00*
Dedicated	***Grand Total***		***887.00***	***63,833.00***	***199,012.00***	***5,996.00***	***1,943.00***	***232,668.00***

Table 3. Damage Type/Damaging Agent Key for Table 2

Damage Type	Insect species-host
Defoliator	Lodgepole pine needle cast
Defoliator	Pandora moth
Defoliator	Pine needle scale
Defoliator	Spruce aphid
Defoliator	Tent catepillar
Defoliator	Western hemlock looper
Defoliator	Western oak looper
Defoliator	Western spruce budworm
Mortality	Bear
Mortality	Douglas-fir beetle
Mortality	Engelmann spruce beetle
Mortality	Fir engraver
Mortality	Fire
Mortality	Flatheaded woodborer
Mortality	Mountain pine beetle, Jeffrey pine
Mortality	Mountain pine beetle, lodgepole pine
Mortality	Mountain pine beetle, ponderosa pine
Mortality	Mountain pine beetle, sugar pine
Mortality	Mountain pine beetle, w. white pine
Mortality	Mountain pine beetle, whitebark pine
Mortality	Oregon pine ips
Mortality	Port Orford cedar root disease
Mortality	Silver fir beetle
Mortality	Water
Mortality	Western balsam bark beetle
Mortality	Western pine beetle
Mortality	Western pine beetle, small trees
Other damage	Balsam woolly adelgid
Other damage	Blister rust
Other damage	Cytospora canker
Other damage	Douglas-fir beetle engraver
Other damage	Dying hemlock
Other damage	Pacific Madrone decline
Other damage	Red belt
Other damage	Root disease
Other damage	Slide
Other damage	Wind
Other damage	Winter damage

APPENDIX 4
Surface Water
Supply Index

SURFACE WATER SUPPLY INDEX

The Surface Water Supply Index (SWSI) is a drought index originally developed by the Natural Resources Conservation Service. It was modified to reflect Oregon's water conditions and is used by the Oregon Drought Council to monitor drought status. The SWSI ranges from -4.1, which indicates extreme drought, to +4.1, which indicates extremely wet conditions. Zero indicates average conditions.

The index incorporates the four parameters of rainfall, snow, streamflow, and reservoir information from stations in each climate basin. However, not all basins have all four data types. The parameters are weighted specifically for each basin which makes the index indicative of the local (basin) conditions. There is also a time lag coefficient incorporated in the index to minimize short-term fluctuations while still providing an indication of a basin's longer term drought status.

This SWSI explanation provided by Mike Ziolko, climatologist for the Oregon Department of Forestry.