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The Status of Whitebark Pine Along the Pacific Crest National Scenic Trail on the Umpqua National Forest

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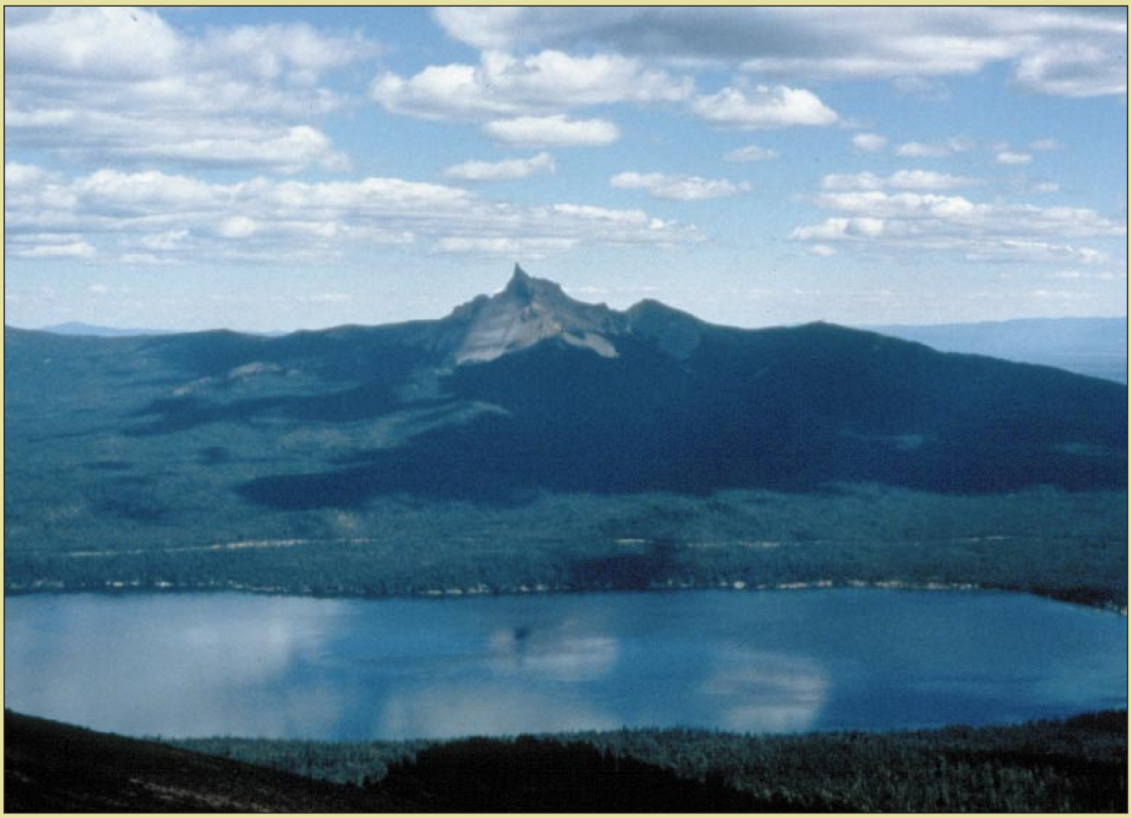

Forest Health Monitoring

West Coast Region

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Cover photo: Mount Thielsen as viewed from Mount Bailey. Photograph by Robert Danchok.

Abstract

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Because of concern over widespread population declines, the distribution, stand conditions, and health of whitebark pine (*Pinus albicaulis* Englem.) were evaluated along the Pacific Crest National Scenic Trail on the Umpqua National Forest. Whitebark pine occurred on 76 percent of the survey transects. In general, whitebark pine was found in stands with lower overall densities and fewer late-seral species, particularly Shasta red fir (*Abies magnifica* var. *shatensis* A. Murr.) and mountain hemlock (*Tsuga mertensiana* [Bong.] Carr.). Whitebark pine stocking differed widely, from less than 1 up to 24 percent of the trees on transect plots. Most whitebark pines (87 percent) were less than 5 m tall. Of all whitebark pine encountered, 44 percent were alive and healthy, 46 percent were alive but infected by *Cronartium ribicola* (J.C. Fisch) (cause of white pine blister rust), and 10 percent were dead. Two-thirds of the mortality was due to white pine blister rust. Mountain pine beetle (*Dendroctonus ponderosae* Hopkins) alone accounted for 13 percent of the mortality, whereas evidence of mountain pine beetle was found with white pine blister rust on 18 percent of the dead whitebark pines.

White pine blister rust affected trees in all but the largest size class; 70 percent of the whitebark pines greater than 1.5 m tall and less than 7.6 cm diameter at breast height (d.b.h.) were infected. Most (92 percent) of infected whitebark pines had bole cankers or cankers within 15 cm of the bole. No cones were observed on whitebark pines in any of the survey plots. Whitebark pine was common in centers of laminated root rot (caused by the fungus *Phellinus weirii* (Murrill.) R.L. Gilbertson) where substantial canopy openings were found. In these centers, whitebark pine contributed 73 percent of the large tree stocking. The results of this survey constitute a reference condition for whitebark pine that can be used to assess change in its status in this part of southwest Oregon. Measures to reduce the impacts of disease and bark beetles and to maintain whitebark pine populations are discussed.

Keywords: Whitebark pine, *Pinus albicaulis,* white pine blister rust, *Cronartium ribicola*, mountain pine beetle, *Dendroctonus ponderosae,* Umpqua National Forest.

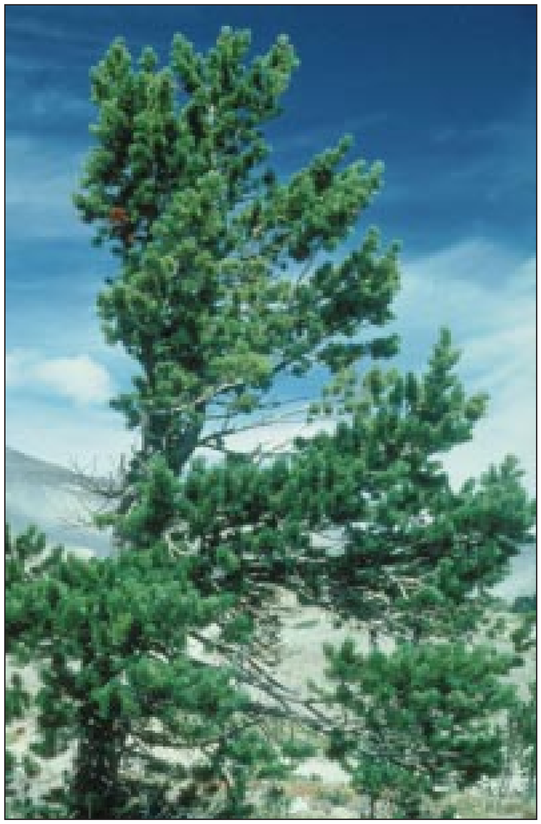

Figure 1—Whitebark pine *(Pinus albicaulis* Engelm). (Photo by Tom Iraci.)

Introduction

Whitebark pine (*Pinus albicaulis* Engelm.) is an important high-elevation forest species in southwestern Canada and the Western United States (Arno and Hoff 1990). It tolerates extreme environmental conditions and may act as a nurse tree, modifying microclimatic conditions so that other, less hardy plant species can become established. It is important for watershed protection, catching and retaining snow, and stabilizing rock and soil on harsh, open areas. It provides cover and roosting sites for wildlife and has considerable aesthetic value (fig. 1). Its large nutlike seeds are high in fat and protein and are important food sources for many mammals and birds.

Whitebark pine belongs to the group of pines known as the "bird pines." These pines have wingless or nearly wingless seeds and depend on the caching or planting of seeds by nutcrackers or jays for regeneration. Whitebark pine is almost entirely dependent on the Clark's nutcracker (*Nucifraga columbiana* Wilson) for its regeneration. Clark's nutcrackers have strong bills that can extract seed from cones, throat pouches that can hold up to 100 seeds, and highly developed long-term memories (Tomback et al. 1990). They use their bills to dig sites for seeds in mineral soils, and they thrust seeds into sandy soil or loose substrates. They cache seeds in various sites, including loose gravelly soil and forest litter; at the base of trees, rocks, and logs; among roots; under rocky rubble; and in holes in trunks or bark of trees. Caching sites have been observed across a wide range of elevations, in burns, harvested areas, forest openings, along lake shores, meadow edges, and on cliffs. Nutcrackers will fly as far as 22 km to cache seeds.

Figure 2—Along the Pacific Crest National Scenic Trail on the Umpqua National Forest, whitebark pine is found in predominantly pure stands at higher elevations (A) and at lower to mid elevations in mixed stands with mountain hemlock, lodgepole pine, western white pine, Pacific silver fir, and Shasta red fir (B). (Photos by Ellen Goheen (left) and Robert Danchok (right).)

Whitebark pine is slow growing and long lived. At treeline, whitebark pine forms "krummholz" stands of shrublike trees (McCaughey and Schmidt 1990). Below the krummholz zone, whitebark pine grows in nearly pure stands of widely spaced trees with diffuse crowns (fig. 2a). At its lower elevations, whitebark pine grows in mixed-species stands where it may be difficult to distinguish its form from that of lodgepole pine (*P. contorta* Dougl. ex Loud.) or western white pine (*P. monticola* Dougl. ex D. Don) (fig. 2b). Whitebark pine seedlings and saplings often are found growing in tight clumps of two or more stems resulting from sprouting of multiseed caches.

There is widespread concern about the status of whitebark pine throughout the West. In the northern Rocky Mountains, whitebark pine has declined over the past 60 years because of three interrelated factors: (1) epidemics of the native insect mountain pine beetle (*Dendroctonus ponderosae* Hopkins); (2) dieback and mortality caused by the introduced pathogen *Cronartium ribicola* (J.C. Fisch), the cause of white pine blister rust; and (3) replacement of whitebark pine by shade-tolerant conifers probably because of fire exclusion (Keane and Arno 1993, Kendall and Arno 1990). In some locations on the east side of Glacier National Park and in the Selkirk Range of northern Idaho, 90 percent of the whitebark pine has been killed. Surveys recently completed in the northern portion of the Intermountain region indicate high white pine blister rust infection levels and the onset of mortality of whitebark pine in many areas (Smith and Hoffman 1998). Particular concerns include increased whitebark pine mortality in the western and southern portions of the Greater Yellowstone ecosystem and high white pine blister rust levels in the Centennial Mountains on the Montana-Idaho border where whitebark pine populations are small, disjunct, and therefore potentially vulnerable to extinction.

Recent evaluations of whitebark pine growing in pure stands as well as in mixed-species stands in northeastern Oregon indicate a range of white pine blister rust infection levels as well as a varied history of mountain pine beetle outbreaks (Schmitt and Scott 1998). White pine blister rust is described as severe on some sites; mortality, particularly among smaller size classes, is readily apparent.

Several whitebark pine sites in eastern Washington also have been surveyed recently to determine cause and level of whitebark pine mortality.[1] Overall mortality of white-bark pine was 12.5 percent; white pine blister rust was the most common cause. White pine blister rust was found on 18.9 percent of the whitebark pines examined.

Although whitebark pine is an important species in the southern Oregon Cascade Range, its condition in this area has not been rigorously evaluated. White pine blister rust came later to the region, relative to other areas with whitebark pine in the Pacific Northwest; as of 1943, it was not known to affect whitebark pine south of Mount Jefferson (Bedwell and Childs 1943). Recent anecdotal accounts suggest that both mountain pine beetle and white pine blister rust profoundly influence the health of whitebark pine, but no quantitative information is available.

The objectives of this investigation were to (1) determine the distribution of whitebark pine along the Pacific Crest National Scenic Trail (PCNST) in the southern Oregon Cascade Range, (2) characterize site and stand conditions where whitebark pine occurs, (3) evaluate the current health of the species, and (4) establish a benchmark of information for comparison in the future.

Methods

During summer 1998, personnel from the Southwest Oregon Forest Insect and Disease Service Center, the Dorena Forest Genetics Resource Center, and the Southwest Oregon Ecology Group began a cooperative effort to assess the condition of whitebark pine in southwest Oregon. We chose the portion of the PCNST on the Umpqua and Winema National Forests and extending from the southern boundary of the Willamette National Forest to the northern boundary of Crater Lake National Park for an initial evaluation (T. 25, 25 1/2, 26, 27, and 28 S., R. 5 1/2, 6, and 6 1/2 E.) (fig. 3). Concentrations of whitebark pine were known to be present along this portion of the PCNST, and the area was relatively easily accessed from a series of side trails.

[1] Hadfield, James; Flanagan, Paul. 2000. Personal communication. Plant pathologist and entomologist. Forest Health Protection, Wenatchee Service Center, Forestry Sciences Lab, 1133 N. Western Ave., Wenatchee, WA 98801.

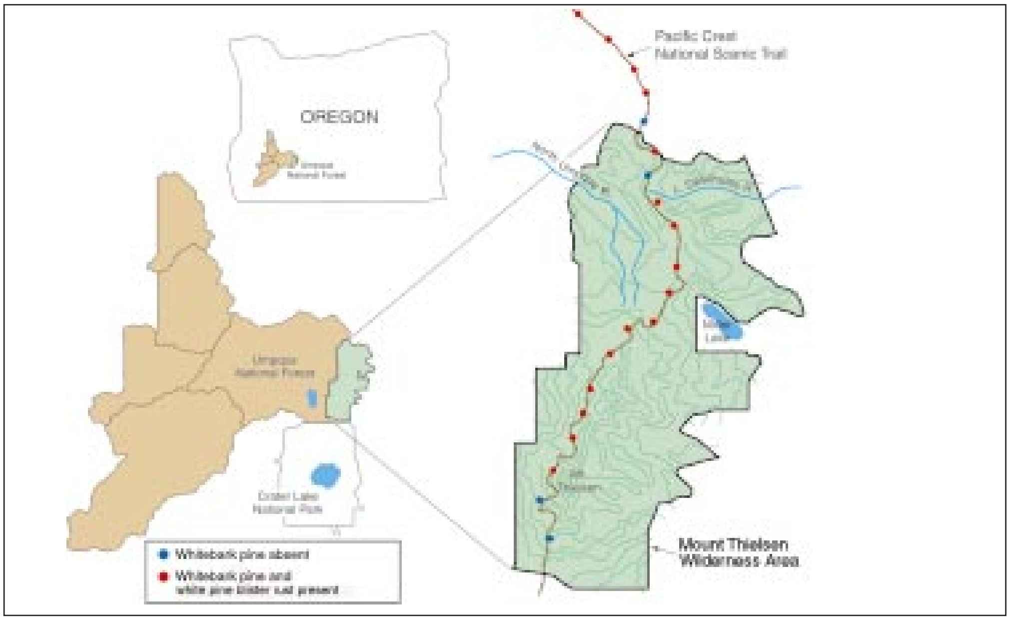

Figure 3—General location of survey area in southwest Oregon and survey transect locations along the Pacific Crest National Scenic Trail, Umpqua National Forest.

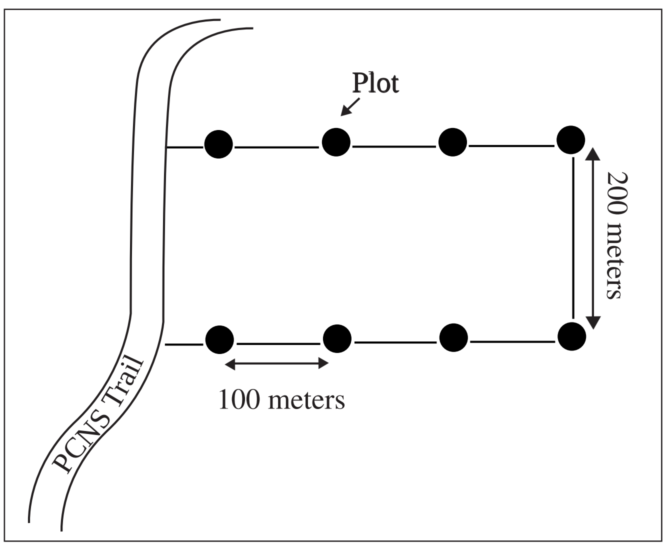

Figure 4—Whitebark pine survey transect design.

Figure 5—Crews collected data at eight plots on each sampling transect. (Photo by Ellen Goheen.)

Transects were installed along the PCNST at each intersection with an east-west section line (fig. 3). The location of each of the 21 transects was determined by topographic features and pacing and was recorded by using a global positioning system device. The transect direction (due east or west of the trail) was randomly determined. Each transect consisted of eight plots systematically located in a U-shaped grid (fig. 4). On each transect, two types of plots were established—six whitebark pine plots and two plots where whitebark pine data plus additional information on all tree species was collected (fig. 5). Data on environmental variables such as plant association (Atzet et al. 1996), slope, aspect, elevation, and topographic position, also were collected on each plot.

Whitebark Pine Plots

Variable-radius plots—A 20-basal-area factor (BAF) variable-radius plot was established for trees greater than 12.7 cm d.b.h. All whitebark pine trees were measured. Other trees were tallied by species.

Fixed-area plots—Circular 0.02-ha plots were established to record whitebark pine trees less than 12.7 cm d.b.h., the number of *Ribes* sp. plants present (the alternate host of *C. ribicola*), and the current root disease severity (table 1).

Table 1—Disease severity rating for plots and trees

Severity rating	Rating definition
Root disease (0.02-ha circular plots):	
0	No evidence of root disease
1	Root disease not on plot, but present within 15 m of plot edge
2	Minor evidence of root disease (i.e., one suppressed tree killed)
3	Canopy reduction up to 20 percent
4	Canopy reduction 20 to 30 percent
5	Canopy reduction 30 to 50 percent
6	Canopy reduction 50 to 75 percent
7	Over 75 percent canopy reduction
8	Only 1 overstory tree remaining due to root disease
9	No overstory trees remaining
Whitepine blister rust (individual trees):	
1	Distance from nearest margin of branch canker to stem >61 cm, nonlethal canker.
2	Distance from nearest margin of branch canker to stem between 15 and 61 cm.
3	Distance from nearest margin of branch canker to stem <15 cm or canker is on bole.

The following data were collected for each whitebark pine tree: condition (living or dead), diameter to the nearest 0.25 cm, height to the nearest 0.3 m, crown ratio, crown class, white pine blister rust canker severity rating (table 1) for the most lethal canker, height to the nearest 0.3 m for the highest white pine blister rust canker, percentage of crown with white pine blister rust cankers, percentage of topkill caused by white pine blister rust, indicators of rodent gnawing on cankers, presence of cones, and other insects and diseases present.

Table 2—Environmental distribution of whitebark pine

Plot category	Elevation range mean (STD)	Aspect range median	Slope range mean (STD[a])	Slope position median location	Plant association occurrence	
	Meters	*Degrees*	*Percent*			*Percent*
Total study area	1768-2320	8-360	1-80	Upper third	TSME14[d]	78
	2024 (149)	227	24 (16)		TSME16[e]	10
					ABMA22[f]	8
					PICO8[g]	4
Large whitebark pines[b]	1783-7610	150-334	2-56	Upper third	TSME14	75
	2063 (184)	227	21 (15)		TSME16	20
					ABMA22	5
					PICO8	0
Small whitebark pines[c]	1780-2304	30-338	2-55	Upper third	TSME14	71
	2003 (146)	222	20 (14)		TSME16	23
					ABMA22	6
					PICO8	0

[a] STD = Standard deviation.
[b] ≥12.7 cm d.b.h.
[c] <12.7 cm d.b.h.
[d] TSME14 = Mountain Hemlock/Grouse Huckleberry/Common Prince's-pine plant association.
[e] TSME16 = Mountain Hemlock/Pinemat Manzanita/Common Prince's-pine plant association.
[f] ABMA22 = Shasta Red Fir-Mountain Hemlock/Pinemat Manzanita/Common Prince's-pine plant association.
[g] PICO8 = Lodgepole Pine-Mountain Hemlock/Depauperate plant association.

All-Tree-Species Plots

Variable-radius plots—A variable-radius plot was established by using a 20-BAF prism to record all trees greater than 12.7 cm d.b.h. Tree species and diameter to the nearest 0.25 cm were recorded.

Fixed-area plots—Circular 0.02-ha plots were established to record the number of *Ribes* sp. plants present and a root disease severity rating (table 1). Circular 0.004-ha plots were used to tally condition of all trees of any species less than 12.7 cm d.b.h. White pine blister rust canker severity rating for the most lethal canker was recorded on infected western white pine (table 1). Trees were grouped into the following diameter classes: (a) trees between 15 cm and 1.3 m tall, (b) trees 0.25 to 2.3 cm d.b.h., (c) trees 2.5 to 7.4 cm d.b.h., and (d) trees 7.5 to 12.5 cm d.b.h.

Results

Distribution of Whitebark Pine

Four plant associations were recorded in the study area: Mountain Hemlock/Grouse Huckleberry/Common Prince's-pine (TSME14), Mountain Hemlock/Pinemat Manzanita/Common Prince's-pine (TSME16), Shasta Red Fir-Mountain Hemlock/Pinemat Manzanita/ Common Prince's-pine (ABMA22), and Lodgepole Pine-Mountain Hemlock/Depauperate (PICO8). Whitebark pine occurred in the Mountain Hemlock and Shasta Red Fir plant associations in proportion to its abundance across the landscape. Whitebark pine was not found in the Lodgepole Pine association, although the sample size was small (table 2).

Plot elevations ranged from 1758 to 2306 m, with a mean of 2012 m. Both large (≥12.7 cm d.b.h) and small (<12.7 cm d.b.h) whitebark pines were distributed over this elevation range (table 2).

Table 3—Tree species composition of area sampled based on all-tree-species plot data

Plot category	Plots	Shasta red fir	Pacific silver fir	Lodgepole pine	Western white pine	Mountain hemlock	Whitebark pine
Basal area:				*Meters² per hectare*			
Total, all-tree-species plots	42	4.7[a]	0.1	6.8	1.7	47.9	0.6
		(0.7)	(0.02)	(1.1)	(0.3)	(7.9)	(0.1)
All-tree-species plots with whitebark pine present	18	1.3	0	7.1	1.5	33.2	1.3
		(0.3)	(0)	(1.7)	(0.4)	(7.8)	(0.3)
Trees per hectare:				*Trees per hectare*			
Total, all-tree-species plots	42	252.3	0	334.3	75.1	1,233.5	111.7
		(39.0)	(0)	(51.6)	(11.6)	(190.3)	(28.2)
All-tree-species plots with whitebark pine present	18	92.4	0	350.1	65.2	821.1	260.4
		(21.7)	(0)	(82.5)	(15.3)	(193.2)	(46.9)

[a] The mean value is given with the standard error in parentheses below it. Basal area is calculated for trees of 12.7 cm d.b.h. or more. Trees per hectare include trees in all size classes.

Study plots were located on virtually all aspects. Large whitebark pines occurred on aspects between 150 and 334 degrees, and small whitebark pines between 30 and 338 degrees. No whitebark pines were recorded on the most northerly aspects (338 to 30 degrees), and only smaller trees were found on the east aspects (30 to 150 degrees) (table 2). The percentage of slope of the plots ranged from 1 to 80 percent, with a mean of 24 percent. Both large and small whitebark pines were found on slopes up to 55 percent, but none were found on the steeper slopes (57 to 80 percent). The median slope position found in the study was the upper third of slope, where whitebark pines also occurred most frequently.

Stand Characteristics

Whitebark pine occurred on 76 percent of the transects. Five tree species occurred with whitebark pine: Shasta red fir (*Abies magnifica* var. *shastensis* A. Murr.), Pacific silver fir (*A. amabilis* Dougl. ex Forbes), lodgepole pine, western white pine, and mountain hemlock (*Tsuga mertensiana* (Bong.) Carr.). Mountain hemlock was clearly the predominant species.

Table 3 shows species occurrence over all the tree-species plots compared with only those tree-species plots where whitebark pine was present. The basal area data are based on results for only the large trees (d.b.h $\geq$12.7 cm), whereas the stocking data (trees per hectare) are derived from trees in all size classes. In general, whitebark pine occurs in stands with lower overall densities and fewer late-seral species. Shasta red fir and mountain hemlock are less abundant on plots with whitebark pine than on other plots.

Table 4—Live tree stocking (trees per hectare) by species and transect

Transect	ABMAS[a]	ABAM[b]	PICO[c]	PIMO[d]	TSME[e]	PIAL[f]	Total
1	415	0	203	143	8,972	262	9,995
2	4,490	0	185	57	2,646	7	7,393
3	9,558	0	0	128	2,896	0	12,582
4	262	0	168	49	1,334	15	1,829
5	3,857	0	0	324	1,043	0	5,224
6	494	0	0	124	635	227	1,480
7	124	0	0	0	5,243	40	5,407
8	153	0	195	2	3,005	138	3,494
9	0	0	5,112	0	7,149	484	12,745
9.5	0	0	1,112	0	2,412	509	4,033
10	0	0	0	0	1,198	52	1,250
11	0	0	324	0	749	222	1,295
12	0	0	0	0	6,239	44	6,284
13	0	0	0	0	3,941	106	4,047
14	0	0	0	0	1,463	136	1,599
15	0	0	2,995	0	2,150	148	5,293
16	0	0	141	0	8,527	0	8,668
17	492	0	633	49	5,243	0	6,417
18	502	0	484	0	3,924	0	4,910
19	0	0	326	10	331	208	875
20	0	1,619	568	72	714	111	3,084
Mean	969	77	652	46	3,325	129	5,138
Standard error	506	77	271	17	577	33	795

[a] ABMAS = Shasta red fir.
[b] ABAM = Pacific silver fir.
[c] PICO = lodgepole pine.
[d] PIMO = western white pine.
[e] TSME = mountain hemlock.
[f] PIAL = whitebark pine.

Stocking levels for all the tree species varied widely among individual transects. Total stocking on individual transects ranged from 875 to 12,745 trees per hectare (table 4). Average basal area for all species on individual transects ranged from 27.0 to 76.9 m^2 per ha (table 5).

Whitebark Pine Stocking

Whitebark pine stocking varied widely among transects (table 4). Where whitebark pine occurred, stocking for living and dead trees of all sizes ranged from 7 to 509, with an average of 169 trees per hectare. Whitebark pine stocking represented from less than one percent up to 24 percent of the total trees per hectare. When only small trees (<12.7 cm d.b.h) were considered, whitebark pine stocking ranged from less than one percent to 32 percent of the trees per hectare.

Table 5—Live tree basal area (square meters per hectare) by species and transect

Transect	ABMAS[a]	ABAM[b]	PICO[c]	PIMO[d]	TSME[e]	PIAL[f]	Total
1	2.9	0	6.9	4.6	15.5	2.9	32.7
2	25.8	0	1.1	5.2	21.8	0	54.0
3	4.6	0	0	1.1	71.2	0	76.9
4	20.1	0	1.7	3.4	43.1	.6	68.9
5	25.8	0	0	1.7	25.8	0	53.4
6	0	0	1.1	.6	46.5	.6	49.9
7	0	0	4.6	.6	54.0	0	59.1
8	1.1	0	8.0	1.1	36.2	0	46.5
9	0	0	6.9	0	19.5	.6	27.0
9.5	0	0	1.1	0	43.1	.6	44.8
10	0	0	1.7	0	53.4	0	55.1
11	0	0	2.3	0	28.7	3.4	34.4
12	0	0	0	0	45.3	0	45.3
13	0	0	0	0	56.3	1.7	58.0
14	0	0	0	0	60.8	1.1	62.0
15	0	0	8.0	0	30.4	1.7	40.2
16	0	0	3.4	0	55.1	0	58.5
17	5.2	0	32.1	4.6	10.3	0	52.2
18	6.9	0	6.9	0	57.4	0	71.2
19	0	0	2.3	2.3	48.2	.6	53.4
20	0	2.9	5.7	1.1	41.9	.6	52.2
Mean	4.4	.7	4.5	1.3	41.2	.7	52.2
Standard error	1.9	.6	1.5	.4	3.6	.2	2.8

[a] ABMAS = Shasta red fir.
[b] ABAM = Pacific silver fir.
[c] PICO = lodgepole pine.
[d] PIMO = western white pine.
[e] TSME = mountain hemlock.
[f] PIAL = whitebark pine.

Eighty-seven percent of all whitebark pine measured were less than 5 m tall. The largest whitebark pine tree measured on survey plots was 68 cm d.b.h. Larger individuals were occasionally encountered in surrounding stands.

Whitebark Pine Health

White pine blister rust occurred on all transects with whitebark pine (figs. 6, 7, and 8). Across the entire survey area, 44 percent of all whitebark pine encountered were alive and healthy, 46 percent were alive but infected by *C. ribicola*, and 10 percent were dead (fig. 8)

On individual transects, white pine blister rust occurrence on living trees varied widely, ranging from zero to 100 percent (table 6).

Figure 6—Whitebark pine is frequently infected and killed by white pine blister rust. (Photo by Robert Danchok.)

Figure 7—Infections of the bole by *Cronartium ribicola*, cause of white pine blister rust, are considered lethal. Note “blisters” of rust spores erupting from bark of this whitebark pine tree. (Photo by Ellen Goheen.)

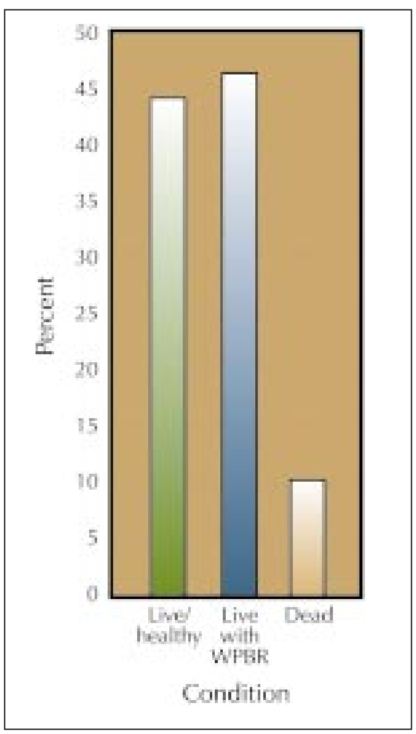

Figure 8—Percentage of whitebark pine by condition classes. WPBR = white pine blister rust.

Table 6—Whitebark pine stocking (trees per hectare) by condition and transect

	Live		Dead			
Transect	Uninfected	Infected WPBR[a]	WPBR	WPBR and MPB[b]	MPB	Other
1	37.1	224.9	19.8	4.9	0	0
2	0	7.4	0	7.4	0	0
4	14.8	0	7.4	0	0	0
6	135.9	91.4	44.5	0	17.3	0
7	7.4	32.1	24.7	32.1	0	0
8	69.2	69.2	0	0	2.5	0
9	197.7	286.6	37.1	0	0	0
9.5	254.5	254.5	19.8	4.9	0	0
10	44.5	7.4	0	0	0	0
11	138.4	84.0	0	0	0	0
12	37.1	7.4	0	0	0	0
13	32.1	74.1	0	0	4.9	0
14	74.1	61.8	7.4	0	0	7.4
15	86.5	61.8	0	0	0	0
19	131.0	76.6	17.3	0	9.9	0
20	56.8	54.4	0	0	0	0
Mean	82.3	87.1	11.1	3.1	2.2	.5
Standard error	17.9	22.3	3.6	2.0	1.2	.5

[a] WPBR = white pine blister rust.
[b] MPB = mountain pine beetle.

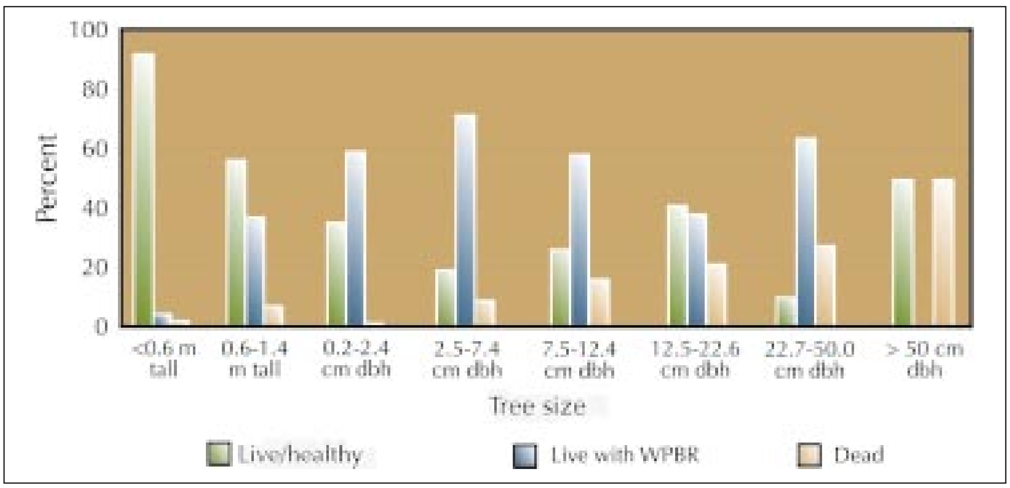

Figure 9—Percentage of whitebark pine by size and condition class (uninfected, infected with white pine blister rust (WPBR), or dead).

White pine blister rust affected trees in all but the largest size class (trees >51 cm d.b.h) (fig. 9). Infection levels were low in trees between 15 cm and 0.6 m tall. On the other hand, 70 percent of the whitebark pines greater than 1.5 m tall and less than 7.6 cm d.b.h were infected.

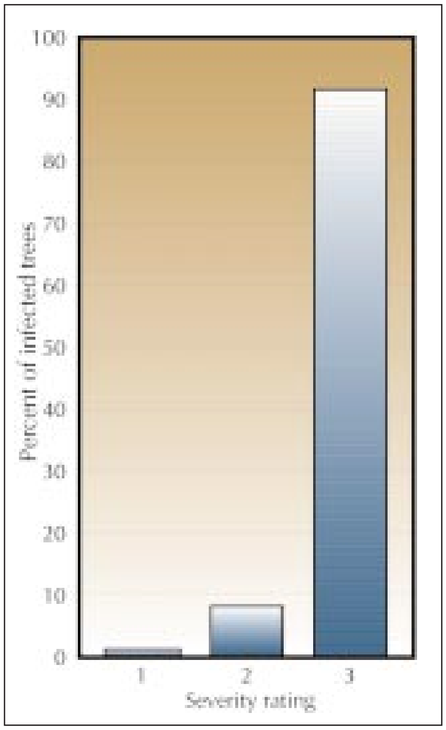

Figure 10—Percentage of whitebark pine by white pine blister rust severity classes.

Figure 11—Tops of about a third of the whitebark pine in the Umpqua Pacific Crest National Scenic Trail survey were killed by white pine blister rust. (Photo by Ellen Goheen.)

Most (92 percent) of the infected whitebark pine were classified as WPBR severity rating 3; they had bole cankers or cankers within 15 cm of the bole (fig. 10). Eight percent of infected trees had cankers located between 15 and 61 cm from the bole (severity rating 2), and less than one percent of the infected trees had cankers at a distance greater than 61 cm from the bole (severity rating 1).

Thirty-four percent of all live whitebark pines with white pine blister rust had been top-killed (fig. 11); the proportion of the top that had been killed was greater than 30 percent of the height of the tree in 43 percent of the trees with topkill. Topkill excluded, white pine blister rust cankers commonly killed branches constituting 10 to 20 percent of the live crown. Cankers were found throughout the heights of the trees (fig. 12).

White pine blister rust was the most frequently encountered whitebark pine mortality agent, accounting for 66 percent of all dead trees (table 6). Evidence of mountain pine beetle was found with white pine blister rust on 18 percent of dead whitebark pines. Mountain pine beetle alone killed 13 percent of the whitebark pine examined in the survey (fig. 13). The largest whitebark pine (68 cm d.b.h) measured in survey plots had recently been killed by mountain pine beetles. Other large whitebark pine snags of various age and decay categories were observed in the surrounding stands. Many showed evidence of attack by mountain pine beetles.

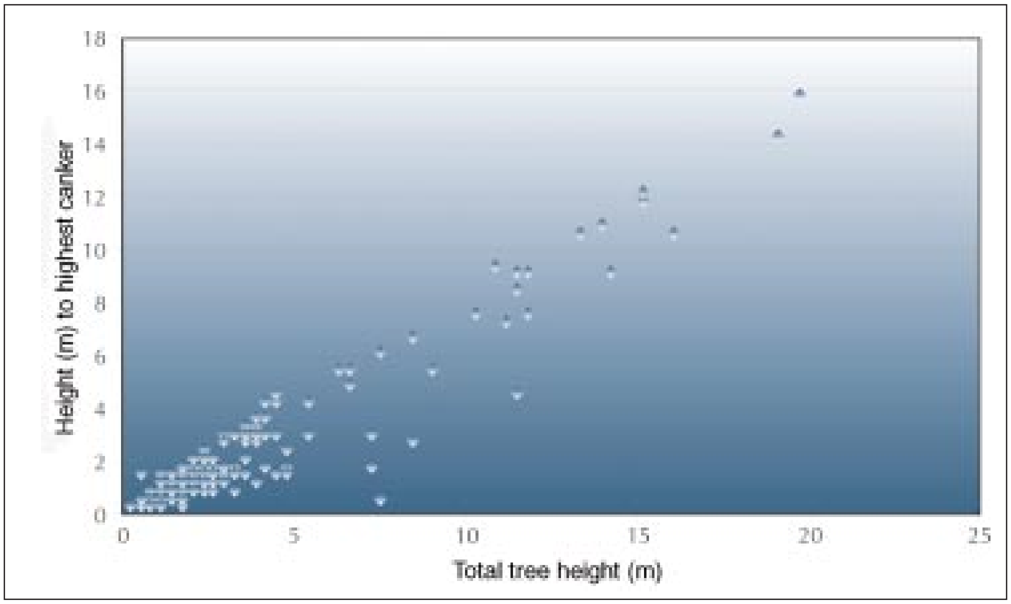

Figure 12—Height of highest white pine blister rust cankers on whitebark pine, by tree height.

Figure 13—Mountain pine beetles frequently contribute to mortality of whitebark pine. (Photo by Ellen Goheen.)

Figure 14—Whitebark pine is an important pioneer species inside openings caused by laminated root rot. (Photo by Ellen Goheen.)

Table 7—Number of plots in root disease severity rating categories

Root disease severity rating	0	1	2	3	4	5	6	7	8	9
Number of plots	96	13	19	11	8	11	4	3	2	1

Only one *Ribes* plant was encountered across the entire survey area. It was found along the PCNST near one of the few springs in the area but was not associated with any transect or survey plot.

Evidence of rodents chewing on white pine blister rust cankers was seen on only four trees measured in the survey.

No cones were observed on whitebark pines in any of the survey plots.

Root Disease

Laminated root rot (caused by the fungus *Phellinus weirii* (Murrill) R.L. Gilbertson) was found on 59 (35 percent) of the survey plots (fig. 14). Canopy reduction caused by laminated root rot was considered minor (RDSR = 2) on 19 plots, moderate (RDSR = 3, 4, or 5) on 30 plots, and high (RDSR = 6, 7, 8, or 9) on 10 plots (table 7). Mountain hemlock, a highly susceptible species, was the main tree being impacted by *P. weirii*.

Whitebark pines occurred on only 32 percent of all plots with root disease (RDSR $\geq$ 2), but that frequency more than doubled to 70 percent of the plots with high levels of canopy reduction due to root disease (RDSR $\geq$ 6). On these plots, whitebark pines comprised 49 percent of the stocking for trees of all sizes, followed by lodgepole pine

(39 percent), and western white pine (12 percent). Seventy-three percent of the trees greater than 25 cm d.b.h. found in plots with high RDSR were whitebark pines; the remainder were western white pines. There was no evidence of damage to whitebark pine, western white pine, or lodgepole pine owing to *P. weirii* in this survey.

Discussion

Anecdotal accounts are no longer the only source of whitebark pine information along the PCNST on the Umpqua National Forest. The 1998 reference condition for whitebark pine described in this report can be used for assessing changes in the status of the species in this area.

Along this portion of the PCNST, whitebark pine usually occurs as a minor component in predominantly mixed-species stands, but stocking levels are variable. Higher frequencies of whitebark pine on upper slope south-facing sites; open, rocky ridgetops; in areas with increased lodgepole pine stocking levels; and in openings created by laminated root rot point to its affinity for areas of recent disturbance and open stand conditions.

Half of the whitebark pine stocking is currently infected by *C. ribicola*. White pine blister rust is obviously having a significant effect on form and function of whitebark pine; two-thirds of current mortality is due to *C. ribicola*. Topkill caused by the fungus is affecting height growth in an already slow-growing species; substantial portions of the main stems are dead, and lateral branches are competing to replace the leaders. The high proportion of trees with cankers near or on the bole suggests that there will be considerably more topkill and tree mortality.

No obvious, distinct pattern indicating wave-year *C. ribicola* infections was observed in this survey, but no systematic attempt was made to age white pine blister rust cankers. The lack of *Ribes* spp. present near infected trees and in the survey area in general, as well as the distribution of white pine blister rust cankers throughout the heights of infected trees, strongly support the hypothesis that the *C. ribicola* basidiospores that infect pine in the survey area originate in other locations and are brought to the area via clouds and fog. Such environmental conditions are common in late summer and early autumn in the southern Oregon Cascade Range, particularly at the higher elevations. Thus, white pine blister rust likely will continue to cause branch dieback, topkill, and mortality in these whitebark pine forests.

Although no whitebark pine cones were observed on plot trees during the 1998 survey, cones were present on scattered whitebark pines observed outside the plots. Numbers of cone-producing whitebark pines will undoubtedly be influenced by the presence of white pine blister rust. Topkill in larger trees physically reduces the cone-bearing portion of the tree, and fewer trees surviving to cone-bearing age will result in fewer cones produced overall.

Larger diameter whitebark pines have been killed both recently and in the past by mountain pine beetles operating alone or in conjunction with white pine blister rust. Mountain pine beetles typically attack and kill mature whitebark pine; individual tree mortality associated with endemic population levels involves weaker, less vigorous trees (Furniss and Carolin 1977). More than half of the trees killed by mountain pine beetles in the survey area also had evidence of *C. ribicola* infection. There was little evidence of white pine blister rust on dead trees greater than 51 cm d.b.h., but because most of these trees had been dead for a considerable time, detection of past disease was extremely difficult. In other areas of the West, it has been shown that, during outbreaks, whitebark pine stands are often infested by mountain pine beetles originating in lower elevation lodgepole pine stands (Bartos and Gibson 1990). Relatively pure lodgepole pine stands were found in the survey area.

In several openings created by laminated root rot, whitebark pine, which is resistant to *P. weirii*, was the only regenerating species. On one of these plots, however, all the whitebark pines were infected by *C. ribicola*. On other plots with extensive root disease, lodgepole pine and western white pine, also highly resistant to *P. weirii*, were also present. Although western white pine was not sampled intensively in this survey, limited data indicate that 63 percent of the western white pines were infected by *C. ribicola* as well. Thus it seems reasonable to assume that the dynamics of trees inside openings created by laminated root rot are, and will continue to be, substantially altered owing to the impacts of white pine blister rust. Regeneration of root-disease-resistant species will shift from a mix of resistant pine species to predominantly lodgepole pine. Stocking levels may be reduced inside root disease pockets where lodgepole pine is unavailable or unsuitable for the site. Large tree structure in root disease pockets in stands of whitebark pine and western white pine will decrease because of lack of recruitment, mortality and topkill at young ages, and the potential increased vulnerability of infected large trees to attack by mountain pine beetles.

Although no wildlife-related data on standing dead whitebark pines were collected in the survey, woodpeckers were observed excavating in large-diameter (>51 cm. d.b.h.) dead whitebark pines, and bats were seen emerging from beneath the loose bark of one large whitebark pine snag. Decreased survival of regeneration, slower growth rates related to topkill, and mountain pine beetle-caused mortality may affect numbers of replacement whitebark pine and western white pine snags available to cavity nesters and other wildlife species. Fewer whitebark pine cones will be available as a food source for Clark's nutcrackers as well as for other birds and mammals.

Our overall impression after completing this investigation is that whitebark pine in the survey area is more seriously threatened by white pine blister rust than previously believed. Maintaining the whitebark pine component in this area seems critical in light of its importance on certain microsites and in root disease centers.

Possible measures to reduce impacts of white pine blister rust on whitebark pine in the survey area could include:

- Increased use of prescribed fire for creating openings where pine regeneration would be encouraged and host populations might be enlarged sufficiently for natural resistance to *C. ribicola* to emerge.
- Breeding to enhance resistance of phenotypically resistant whitebark pines identified in the field, for planting in appropriate locations in an active restoration program.

Possible measures to reduce the impacts of mountain pine beetle on whitebark pine could include:

- Reducing ingrowth of late-seral species, such as mountain hemlock and true firs, and reducing the basal area of whitebark pine and lodgepole pine in stands mechanically or with fire to increase individual tree vigor.

- Suppressing mountain pine beetle populations in lower elevation lodgepole pine stands to reduce numbers of mountain pine beetles invading higher elevation whitebark pine stands.

The area sampled along the PCNST should be revisited to monitor how the structure and function of whitebark pine forests on the Umpqua National Forest will be influenced by white pine blister rust.

The PCNST on the Umpqua National Forest misses several high-elevation ridges where whitebark pine grows in essentially pure stands. These sites will be surveyed in the near future to ascertain how whitebark pines growing under more extreme environmental conditions are being affected by white pine blister rust and mountain pine beetles. Surveys also will be conducted in other parts of southwestern Oregon as resources become available.

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English Equivalents

When you know:	Multiply by:	To find:
Centimeters (cm)	2.54	Inches
Hectares (ha)	2.47	Acres
Kilometers (km)	0.621	Miles
Meters (m)	3.281	Feet
Square meters (m^2)	1.20	Square yards

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