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is a lack of specific data base for projecting the potential of this disease on lodgepole pine. Therefore, this study was developed to establish the distribution of stalactiform blister rust in Idaho lodgepole pine forests and the environmental conditions in which this rust disease can occur.

MATERIALS AND METHODS

Locations in Idaho of lodgepole pine infected with stalactiform blister rust were obtained from survey procedures developed by the Forest Pathology Unit, College of Forestry, Wildlife and Range Sciences at the University of Idaho (4, 8) and through responses to a request of ranger district personnel of the United States Forest Service.

The survey records provided locations of plots containing lodgepole pine. Each plot record indicated the presence or absence of stalactiform blister rust, notations regarding other disease and insect problems, elevation, habitat type, position on slope, percent slope, and aspect.

Habitat classifications used for the Clearwater and Idaho Panhandle National Forests were those of Daubenmire and Daubenmire (2). The classifications used for the following areas were developed by Steele, et al., the Bitterroot and Nez Perce National Forests (9), the Boise, Challis, Payette, Salmon, and the north half of the Sawtooth National Forests (11), and the Caribou, south half of the Sawtooth, and the Targhee National Forests (10).

The descriptions of positions on slopes followed the classes used by Geils (4):

"ridge," mountain summit and associated summit ridges;

"upper," upper one-third of north and east slopes or upper two-thirds of west and south slopes;

ABSTRACT

Stalactiform blister rust, caused by *Cronartium coleosporioides*, occurs on hard pines throughout North America. Locations of lodgepole pine reported in disease surveys of Idaho forests, 1968-1980, showed stalactiform blister rust to occur between 1500 m and 2438 m. *Abies lasiocarpa/Xerophyllum tenex* and *A. lasiocarpa/Vaccinium scoparium* are the most common habitat types supporting lodgepole pine and stalactiform blister rust. The rust occurred independently of many disease and insect problems found on lodgepole pine during the survey.

Additional Key Words: *Peridermium stalactiforme*, pine stem rust

INTRODUCTION

Stalactiform blister rust, caused by *Cronartium coleosporioedes* Arth., is a disease of hard pines in North America causing cankers which reduce volume and which cause some mortality in all age classes. The distribution of lodgepole pine is from southeastern Alaska and the interior Yukon Territory to northern Baja California and east to the Black Hills of South Dakota (3). Stalactiform blister rust occurs in much of the lodgepole pine areas and in the jack pine (*Pinus banksiana* Lamb.) area of north central United States and Canada (1, 5, 7, 12). The lodgepole pine host (*Pinus contorta* Dougl.) is divided into three geographical varieties, eastward, *P. contorta* var. *latifolia* Engelm., westward, shore pine, *P. contorta* var. *contorta*, and Cascades and Sierra Nevada, *P. contorta* var. *murrayana* (Grev. & Balf.) Engelm. While the host distribution and effects of this disease are generally known, there

"middle," lower two-thirds of north and east slopes or lower one-third of west and south slopes;

"lower," gentle slopes adjacent to valley floors;

"flat," dry benches with no dominant drainage direction; and

"wet," stream bottom, meadows, or valley floors.

Aspect of the slope was sighted to the nearest ½ compass quadrant. Slope was measured to the nearest 5 percent using a Spiegel Relascope. Plots having no slope were recorded as having no aspect. Elevations were measured with the aid of an altimeter calibrated in 25-foot intervals and then converted to the metric equivalent.

In an attempt to enlarge the stalactiform blister rust survey beyond the limits of our resources and time, a request to report stalactiform blister rusted stands was sent to the supervisors of the following national forests: Bitterroot, Boise, Caribou, Challis, Clearwater, Nez Perce, Payette, Salmon, Sawtooth, Targhee, and the Idaho Panhandle National Forests (Figure 1). Ranger district personnel recorded the township, range, section, habitat type, and elevation of stalactiform blister rusted stands in their areas.

RESULTS

The elevational occurrence of lodgepole pine sampled in 133 locations ranged from 838 m (2750 ft) to 2560 m (8400 ft). Stalactiform blister rust was found to occur in 64 of these locations between the elevations of 1500 m (4925 ft) and 2438 m (8125 ft) (Tables 1, 2, 3, and Figure 1).

Earlier survey records of the Forest Pathology Unit did not specifically include stalactiform blister rust but instead inventoried mechanical damage and scars not caused by fire (Table 2). Because

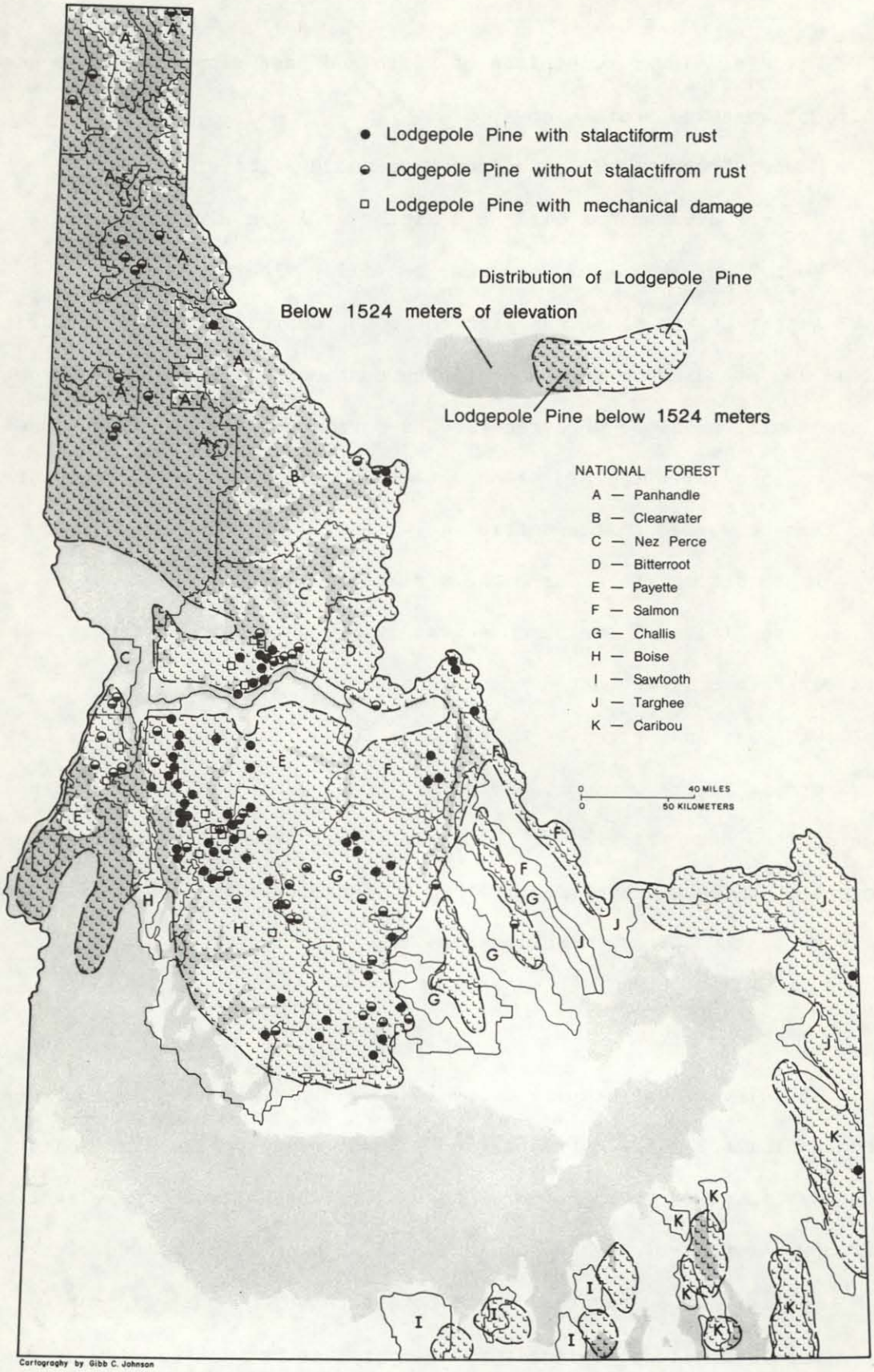

Figure 1. Locations of lodgepole pine with and without stalactiform blister rust recorded through 1980.

mechanical damage to bark and stalactiform blister rust cankers are similar in appearance and because stalactiform rust was found in the same vicinities during later surveys, these notations of damage are accepted as locations of lodgepole pine infected with stalactiform blister rust (Figure 1).

TABLE 1. Reported locations of stalactiform rust in Idaho.

Plot Number	Elevations (m)	Habitat type	Position on slope	Slope (%)	Aspect
		BOISE NATIONAL FOREST			
700805	2000	Abla/Caca[d]	Middle	20	E
780715S[a]	1951	-	-	-	-
790601S	1700	-	-	-	-
790607	2000	Abla/Caca	Lower	20	W
790608N[b]	1670	Abla/Caca	Middle	60	E
790609N	2100	Abla/Caca	Flat	0	-
790610N	1900	Abla/Caca	Lower	10	W
790611N	1600	Abla/Caca	Lower	10	W
801001F[c]	1829	Pico/Vaca	-	-	-
		CARIBOU NATIONAL FOREST			
801009F	1950	Abla/Caca	-	-	-
		CHALLIS NATIONAL FOREST			
780705	2316	Abla/Cage	Lower	10	NW
780707S	1890	-	-	-	-
780708	2012	-	Wet	0	-
780712S	2073	-	-	-	-
780713	2316	Abla/Cage	Middle	50	W
780716S	2256	-	-	-	-
790903S	2438	-	-	-	-
801008F	2134	Pico/Caru	-	-	-
		CLEARWATER NATIONAL FOREST			
780603	1680	Abla/Vaca	Flat	0	-
780604S	1554	-	-	-	-
		NEZ PERCE NATIONAL FOREST			
740706	1935	Abla/Stam	Upper	10	SW
740708	1890	Abla/Xete	Ridge	10	SW
7808101	1829	Abla/Vasc	Flat	0	-
7808102	1829	Abla/Xete	Upper	10	S

7808104	1829	Abla/Xete	Flat	0	-
7808105	1951	Abla/Xete	Ridge	0	-
		PANHANDLE NATIONAL FORESTS			
780815N	1890	Abla/Xete	Ridge	0	-
790612N	1550	Abla/Xete	Ridge	20	W
		PAYETTE NATIONAL FOREST			
760704	1617	-	Flat	5	W
760708	1629	-	Flat	5	W
760709	1634	-	Flat	5	W
760710	1547	-	Flat	0	S
760712	1524	-	Lower	10	S
780852N	1800	-	Wet	0	-
		SALMON NATIONAL FOREST			
780629	1890	Abla/Vasc	Middle	80	NE
780633N	1829	-	-	-	-
780634N	2377	-	-	-	-
780635N	2073	-	-	-	-
		SAWTOOTH NATIONAL FOREST			
790710	1900	Abla/Cage	Lower	20	E
790711	2134	Abla/Arco	Wet	0	-
790910N	2377	Abla/Cage	Lower	0	-
790911S	2415	-	-	-	-
801002F	2042	-	-	-	-
801003F	1981	-	-	-	-
801004F	1829	-	-	-	-
801005F	2134	-	-	-	-
801006F	2134	-	-	-	-
		TARGHEE NATIONAL FOREST			
801007F	1951	Psma/Caru	-	-	-

[a]S = Stalactiform rust found in section but not on plot.

[b]N = Nonrandom plots.

[c]F = Locations from United States Forest Service.

[d]Abla/Arco = *Abies lasiocarpa/Arnica cordifolia*; Abla/Caca = *A. lasiocarpa/Calamagrostis canadensis*; Abla/Cage = *A. lasiocarpa/Carex geyeri*; Abla/Stam = *A. lasiocarpa/Streptopus amplexifolius*; Abla/Vaca = *A. lasiocarpa/Vaccinium caespitosum*; Abla/Vasc = *A. lasiocarpa/Vaccinium scoparium*; Abla/Xete = *A. lasiocarpa/Xerophyllum tenex*; Pico/Caru = *Pinus contorta/Calamagrostis rubescens*; Pico/Vaca = *P. contorta/Vaccinium caespitosum*; Psme/Caru = *Pseudotsuga menziesii/Calamagrostis rubescens*.

TABLE 2. Reported locations of "mechanical damage" lodgepole pine in Idaho.

Plot Number	Elevation (m)	Habitat Type	Position on slope	Slope (%)	Aspect
		BOISE NATIONAL FOREST			
700811	1966	Abla/Vasc[a]	Wet	0	-
700812	1996	Abla/Vasc	Middle	10	E
710701	1554	Abla/Vasc	Middle	5	E
710710	1554	Abla/Vasc	Wet	0	-
710713	1706	Abla/Vasc	Middle	50	W
710717	1706	Abla/Caru	Middle	65	N
710718	1524	Abla/Vasc	Middle	35	NE
710719	1516	Abla/Vasc	Middle	10	NE
760809	1600	Pico/Vagl	Wet	40	SW
760810	1935	Abla/Xete	Middle	30	SE
760827	2012	Pico/Feid	Middle	20	NE
		NEZ PERCE NATIONAL FOREST			
690802	1700	Abla/Xete	Middle	20	SE
690804	1500	Abla/Xete	Middle	25	SW
690807	2000	Abla/Xete	Middle	15	SE
740701	1951	Abla/Xete	Upper	25	E
740705	1920	Abla/Vasc	Upper	35	W
740710	2134	Abla/Vasc	Ridge	5	S
		PAYETTE NATIONAL FOREST			
760764	1935	Abla/Xete	Middle	5	W
760765	1935	Abla/Xete	Middle	15	SW
760843	1524	-	Middle	30	NE
760821	1676	-	Middle	5	SE

[a]Abla/Caru = *Abies lasiocarpa/Calamagrostis rubescens*; Abla/Vasc = *A. lasiocarpa/Vaccinium scoparium*; Abla/Xete = *A. lasiocarpa/Xerophyllum tenex*; Pico/Feid = *Pinus contorta/Festuca idahoensis*; Pico/Vagl = *P. contorta/Vaccinium globulare*.

TABLE 3. Reported locations of lodgepole pine without stalactiform blister rust.

Plot Number	Elevation (m)	Habitat Type	Position on slope	Slope (%)	Aspect
		BOISE NATIONAL FOREST			
700802	2000	Abla/Vasc[a]	-	10	N
700803	1700	Psme/Caru	-	20	E
700804	1700	Psem/Caru	Flat	0	-
700808	2000	Abla/Cage	-	10	SE
700809	1900	Abla/Vasc	Flat	0	-
700810	1951	Pico/Feid	-	10	SE
700811	1951	Abla/Vasc	Flat	0	-
700816	1875	Abla/Vasc	-	5	E
710708	1890	-	Middle	50	NW
760825	1631	Psme/Syal	-	-	-
760835	1585	Abgr/Libo	Middle	50	NE
780725	1859	Abla/Spbe	Upper	0	-
780727	1707	Psme/Caru	Upper	40	E
790605	2400	Abla/Caca	Upper	30	S
790606	1800	Abla/Vasc	Upper	40	NW
790701	1600	Psme/Cage	Middle	20	SE
		CHALLIS NATIONAL FOREST			
780701	2469	Psme/Arco	Middle	10	N
780702	2408	Abla/Juco	Middle	10	SW
780704	2012	Psme/Juco	Lower	0	-
780706	2149	Psme/Arco	Lower	0	-
780710	2134	Abla/Caru	Middle	20	SE
780711	2141	Abla/Vagl	Upper	50	E
780714	2134	Abla/Cage	Middle	20	S
780717	2560	Abla/Caca	Middle	10	S
790903	2316	Abla/Cage	Middle	10	SW
		CLEARWATER NATIONAL FOREST			
780602	1600	Abla/Vaca	Ridge	0	-
780603	1680	Abla/Vaca	Ridge	0	-
780612	1525	Abla/Xete	Upper	0	-
		NEZ PERCE NATIONAL FOREST			
690803	1400	Abla/Xete	-	10	SE
690805	1400	Abla/Xete	Flat	0	-
690810	1600	Abla/Xete	-	10	SE
740701	1814	Abla/Cooc	Upper	25	E
740709	1905	Abla/Stam	Upper	20	SW
740712	2073	Abla/Xete	Upper	15	E
740713	2082	Abla/Xete	Ridge	5	E
780829	1774	Abla/Vagl	Upper	20	N
780823	1844	Abla/Xete	Middle	20	N

		PANHANDLE NATIONAL FORESTS			
680808	869	-	Flat	0	-
680809	914	Abgr/Pamy	Flat	0	-
680814	944	Abgr/Pamy	Ridge	10	-
680822	853	-	-	-	-
720631	1250	Abgr/Pamy	-	20	N
720725	1326	Abgr/Pamy	-	35	W
720813	1097	Abgr/Pamy	-	40	W
740811	838	Psme/Syal	Wet	5	SW
750601	930	Thpl/Atfi	Lower	45	NE
760716	911	Thpl/Pamy	Ridge	20	SW
760729	1341	Tshe/Pamy	Middle	25	S
760737	1024	Thpl/Pamy	Middle	10	SW
770831	1006	Abgr/Pamy	Middle	30	S
770841	1250	Abgr/Pamy	Middle	15	S
		PAYETTE NATIONAL FOREST			
760750	1966	Abla/Xete	Middle	15	S
760759	2057	Abla/Vagl	Middle	30	SW
760766	1835	Abla/Vasc	Middle	20	SW
760809	1570	Pico/Vagl	Wet	40	SW
780804	1625	Abgr/Spbe	Upper	20	SE
780806	1862	Abla/Arco	Upper	30	W
780814	1372	Abla/Vagl	Upper	40	W
780816	1494	Abgr/Vagl	Lower	0	-
		SALMON NATIONAL FOREST			
780624	2286	Abla/Xete	Upper	10	W
		SAWTOOTH NATIONAL FOREST			
790904	2286	-	Lower	0	-
790906	2195	-	Lower	0	-
790914	2600	Abla/Caca	Upper	30	SE

[a]Abgr/Libo = *Abies grandis/Linnaea borealis*; Abgr/Pamy = *A. grandis/Pachistima myrsinites*; Abgr/Spbe = *A. grandis/Spiraea betulifolia*; Abgr/Vagl = *A. grandis/Vaccinium globulare*; Abla/Arco = *A. lasiocarpa/Arnica cordifolia*; Abla/Caca = *A. lasiocarpa/Calamagrostis canadensis*; Abla/Cage = *A. lasiocarpa/Carex geyeri*; Abla/Caru = *A. lasiocarpa/Calamagrostis rubescens*; Abla/Cooc = *A. lasiocarpa/Coptis occidentalis*; Abla/Juco = *A. lasiocarpa/Juniperus communis*; Abla/Spbe = *A. lasiocarpa/Spiraea betulifolia*; Abla/Stam = *A. lasiocarpa/Streptopus amplexifolius*; Abla/Vaca = *A. lasiocarpa/Vaccinium caespitosum*; Abla/Vagl = *A. lasiocarpa/V. globulare*; Abla/Vasc = *A. lasiocarpa/V. scoparium*; Abla/Xete = *A. lasiocarpa/Xerophyllum tenex*; Pico/Feid = *Pinus contorta/Festuca idahonsis*; Pico/Vagl = *P. contorta/Viccinium globulare*; Psme/Arco = *Pseudotsuga menziesii/Arnica cordifolia*; Psme/Cage = *P. menziesii/Carex geyeri*; Psme/Caru = *P. menziesii/Calamagrostis rubescens*; Psme/Juco = *P. menziesii/Juniperus communis*; Psme/Syal = *P. menziesii/Symphoricarpos albus*; Thpl/Atfi = *Thuja plicata/Athyrium filix-foemina*; Thpl/Pamy = *T. plicata/Pachistema myrsinites*; Tshe/Pamy = *Tsuga heterophylla/Pachistima myrsinites*.

The most common habitat type in which lodgepole pine was sampled was *Abies lasiocarpa/Xerophyllum tenex* (Abla/Xete) followed closely by *Abies lasiocarpa/Vaccinium scoparium* (Abla/Vasc). Both of these habitat types occur from mid to upper elevations, on various slopes and aspects, and in them the frequency of lodgepole pine dominates the stand (9, 10, 11). Nearly 40 percent of the plots containing lodgepole pine occurred on these two habitat types, whereas the remaining 60 percent were distributed over the 28 other habitat types.

Because of inadequate habitat type data in some records, only 45 of the 63 locations where rust was found were used to associate stalactiform blister rust with habitat type (Table 4). Ninety-five percent of the 45 locations containing lodgepole pine infected with stalactiform blister rust were in the *Abies lasiocarpa* climax series or *Pinus contorta* climax or community series. The remaining 5 percent were in the *Pseudotsuga menziesii* climax series. *Pinus contorta* is a common seral species in both *Abies lasiocarpa* and *Pseudotsuga menziesii* climax series and may occupy the site through many generations of lodgepole pine before giving way to the competitive ability of the climax species. *Pinus contorta* may persist in compatible habitat types on gentle terrain where cold air pockets exist and the water table fluctuates (9, 10, 11).

At lower elevations, lodgepole pine dominates as a seral in the *Pseudotsuga menziesii* climax series. At upper elevations, *Abies lasiocarpa* was identified as the climax series through the understory vegetation of the *Pinus contorta* community types (9, 10, 11). Warm and dry environmental conditions favor the *Pseudotsuga menziesii* climax series, whereas cool and moist conditions favor *Abies lasiocarpa* climax series. Mid-elevations are transition zones between the *Pseudotsuga*

menziesii and *Abies lasiocarpa* climax series. Throughout this study when *Pinus contorta* community types were encountered and a climax species was not present, the understory vegetations belonged to habitat types in the *Abies lasiocarpa* climax series.

TABLE 4. Frequency of habitat types having lodgepole pine and stalactiform blister rust.

Habitat Types	Number of Plots in each habitat type	with stalactiform blister rust	without stalactiform blister rust
Abies grandix/			
Linnaea borealis	1		1
Pachistima myrsinites	7		7
Spiraea betufolia	1		1
Vaccinium globulare	1		1
Abies lasiocarpa/			
Arnica cordifolia	2	1	1
Calamagrostis canadensis	9	6	3
Calamagrostis rubescens	3	2	1
Carex geyeri	7	4	3
Coptis occidentalis	1		1
Juniperus communis	1		1
Spiraea betulifolia	1		1
Streptopus amplexifolius	2	1	1
Vaccinium caespitosum	4	1	3
Vaccinium globulare	4		4
Vaccinium scoparium	17	11	6
Xerophyllum tenex	23	14	9
Pinus contorta/			
Calamagrostis rubescens	1	1	
Festuca idahoensis	2	1	1
Vaccinium caespitosum	1	1	
Vaccinium globulare	2	1	1
Pseudotsuga menziesii/			
Arnica cordifolia	2		2
Calamagrostis rubescens	4	1	3
Carex geyeri	1		1
Juniperus communis	1		1
Symphoricarpos albus	1		1
Thuja plicata/			
Athyrium filix-foemina	1		1
Pachistima myrsinites	2		2
Tsuga heterophylla/			
Pachistima myrsinites	1		1
Total	103	45	58

The most common habitat types containing infected lodgepole pine were Abla/Xete and Abla/Vasc. The frequencies of stalactiform blister rust present in these habitat types were 31.8 percent and 25.0 percent respectively, and together represented about 56 percent of those containing stalactiform blister rust (Table 4).

The only habitat type in this study where lodgepole pine is the climax species is *Pinus contorta/Festuca idahoensis* (Pico/Feid). This habitat type occurs in broad valleys at upper elevations (9, 10, 11). Two locations in the Boise National Forest representing the Pico/Feid habitat type were sampled. At one location stalactiform blister rust was present in lodgepole pine. The aspect of this location was northeast, whereas the rust-free location was southeast. The elevation of both locations was about 2000 m (6550 ft).

Pseudotsuga menziesii climax series were represented in 9 locations, 5 in the Boise National Forest, 3 in the Challis National Forest, and 1 in the Targhee National Forest (Tables 1, 2, 3). Of these nine locations, only the location in the Targhee National Forest contained stalactiform blister rust. The habitat types in the *Pseudotsuga menziesii* climax series sampled were *Arnica cordifolia* (Psme/Arco), *Calamagrostis rubescens* (Psme/Caru), *Carex geyeri* (Psme/Cage), *Symphoricarpos albus* (Psme/Syal), and *Juniperus communis* (Psme/Juco). Psme/Arco, Psme/Syal, and Psme/Juco occur at lower elevations where environmental conditions are warm and dry (9, 10, 11). Lodgepole pine dominates the Psme/Syal habitat type and may occur in Psme/Arco and Psme/Juco habitat types (9, 10, 11). Psme/Cage occurs at mid to upper elevations where the environmental conditions are cool and dry, but lodgepole pine either is accidental or a minor seral species in some

stands (9, 10, 11). Psme/Caru occurs at mid to upper elevations where the environmental conditions are cool and dry (9, 10, 11), but in central Idaho, lodgepole pine is a minor seral species in some stands (9, 11) and in eastern Idaho, lodgepole pine can dominate the stand (10). The single habitat type which contained stalactiform blister rust was in an eastern Idaho stand where the habitat type was Psme/Caru and lodgepole pine dominated the stand. The environmental conditions were similar to the conditions found in Abla/Xete and Abla/Vasc habitat types.

The possible associations of stalactiform blister rust with other disease and insect problems of lodgepole pine were tabulated for the years 1969-1979 (Table 5). The most common problems found on lodgepole pine, other than stalactiform blister rust, were western gall rust, caused by *Endocronartium harknessii* Y. Hirutsuka, and dwarf mistletoe, *Arceuthobium americanum* Nutt. Western gall rust and dwarf mistletoe appear to occur independently of stalactiform blister rust in that they were found with near equal frequency on both infected and rust-free lodgepole pine.

TABLE 5. Frequency of other diseases and insect problems on lodgepole pine.

Other problems	Number of Trees with stalactiform blister rust	Number of Trees without stalactiform blister rust
Branch:		
Western gall rust (*Endocronartium harknessii*)	10	27
Dwarf Mistletoe (*Arceuthobium americanum*)	10	24
Atropellis canker (*Atropellis piniphila*)		2
Stem:		
Western gall rust	7	16
Red ray rot (*Dichomitus squalens*)	1	1

Red brown butt rot (*Phaeolus schweinitzii*)		1
Fiberous yellow rot (*Echinodontium tinctorium*)		1
Light brown cubical rot (*Fomitopsis rosea*)		2
Blue stain (*Ceratocystis spp.*)		1
Mountain pine beetle (*Dendroctonus ponderosae*)		1
Ipps beetle (*Ipps spp.*)	1	
Unknown bark beetle		4
Roots:		
Honeycombed root rot (*Inonotus tomentosus*)	1	2
Shoestring root rot (*Armillariella mellea*)	1	2
Red ray root rot (*Dichomitus squalens*)	1	1
Stringy root rot (*Perenniporia subacida*)		2
Resinicium bicolor root rot	1	
Collybia radicata root rot		1
Foliage:		
Pine needle rust (*Coleosporium asterum*)	1	
Loose witches broom (*Lophodermium pinastri*)		1
Unknown needle cast	2	11
Budworm-like feeding		1
Sawfly-like feeding		6

The cambium exposed by stalactiform blister rust presumably provides an avenue of entry for decay fungi. However, in 194 lodgepole pine trees sampled in 116 locations, only one decay, caused by *Dichomitus squalens* (Karst) Reid (=*Polyporus anceps* Pk.), was found in one tree of 27 having stalactiform blister rust. Other stem decays were in lodgepole pine without stalactiform blister rust (Table 5).

The University of Idaho survey records for 1969-1979 documented mountain pine beetle on 1 of 194 lodgepole pines sampled. That tree was listed as rust free (Table 5). In these records, rodent feeding on

diseased tissues was noted as prevalent, but no further information was given. In this study, we found no evidence of mountain pine beetle in 68 trees with stalactiform blister rust. Kulhavy et al. (6) reported that mountain pine beetle can successfully attack the margins of stalactiform blister rust cankers on lodgepole pine. He studied trees in 16 stands in 2 central Idaho locations; however, he did not state the number of trees sampled. Eleven of these stands were in the Payette National Forest and 5 in the Nez Perce National Forest. Infected trees or diseased tissues were suggested as excellent host trees for the beetle.

DISCUSSION

The habitat types (9, 10, 11) in which stalactiform blister rust was found to be common had the following characteristics: lodgepole pine was the dominant tree species in the stands, the climates were cool and dry, the stands occurred on mid to upper elevations (1500 m to 2438 m), but the slopes and aspects were variable and nondescriptive (Tables 6, 7). Apparently, middle slope is related to the occurrence of stalactiform blister rust ($P = 0.99$, Table 8); however, we believe this to be bias due to greater number of stands at mid-slope and feel that position on slope is unrelated. Also, no relationship could be shown to percent slope and aspect ($P = 0.65$ and $P = 0.67$, respectively).

The range of environmental characteristics of habitat types (9, 10, 11) indicates that stalactiform blister rust decreases as moisture increases irrespective of temperature. Moreover, when temperature increases, as it does in the range of *Pseudotsuga menziesii* habitat types, specifically of the lower elevations of central Idaho, stalactiform

blister rust also diasppears. In other habitat types temperature was also the limiting factor for stalactiform blister rust distribution. Habitat types containing lodgepole pine that have warm (below 1500 m) or cold to extremely cold (above 2440 m) temperatures do not support stalactiform blister rust. Thus stalactiform rust is limited to a range of approximately 1000 m, between 1500 m (4925 ft) and 2440 m (8125 ft) in Idaho.

TABLE 6. Frequency of lodgepole pine vs. % slope.

Percent Slope	Number of Plots with stalactiform blister rust	Number of Plots without stalactiform blister rust
0	13	15
5	8	3
10	9	10
15	2	2
20	6	11
25	2	2
30	2	5
35	2	0
40	1	6
45	0	1
50	2	2
60	1	0
65	1	0
80	1	0

TABLE 7. Frequency of lodgepole pine vs. aspect.

Aspect	Number of Plots with stalactiform blister rust	Number of Plots without stalactiform blister rust
N	1	5
NE	5	2
E	6	6
SE	4	7
S	3	8
SW	5	9
W	10	5
NW	2	2
Level	11	13

TABLE 8. Frequency of lodgepole pine vs. position on slope.

Position on slope	Number of Plots with stalactiform blister rust	Number of Plots without stalactiform blister rust
Ridge	5	5
Upper	4	15
Middle	20	17
Lower	6	6
Flat	8	0
Wet	6	3

Latitude determines where this 1000 m range is located elevationally. At southern latitudes where average temperatures are warmer, the 1000 m range would be at higher elevations, but would decrease in elevation in the cooler northern latitudes. For example, there were two Pico/Feid locations at about 2000 m elevation, with opposing aspects. The rust was found only on the cooler, wetter northeast aspect.

Stalactiform blister rust is not known to go from pine to pine, and like some other pine rusts, a herbaceous alternate host is involved in completing the life cycle. The reported major alternate hosts, *Castilleja spp.* and *Pedicularis spp.*, are not major components of any habitat type defined in the *Abies lasiocarpa* climax series where lodgepole pine is a component (9, 10, 11) and stalactiform blister rust is frequent. However, *Castilleja spp.* was observed growing in numerous disturbed sites and *Pedicularis spp.* was common in moist locations. Both of these conditions occur with high frequency along many forest roads. Hence, an alternate host, although not present within the stand, is close enough for stalactiform blister rust inoculum to be wind-carried to neighboring stands.

The rust-infected lodgepole pine trees studied in this project apparently were not excellent host trees for stem decays or bark beetle

infestations. Inoculum for decays and beetle populations were present in the study areas, but perhaps not in amounts large enough to overcome unknown physiological mechanisms that prevented their establishment in rusted lodgepole pine. Rodent-feeding on only the diseased tissues indicates that some physiological changes certainly do occur due to rust, but apparently not the changes necessary to encourage establishemnt of other problems. It is likely that the conclusion of Kulhavy et al. (6) regarding the positive mountain pine beetle interaction with rusted lodgepole pine may have been coincidental to an epidemic population of the beetle in the area they studied and therefore did not represent the normal relationships between it and stalactiform blister rust infected lodgepole pine.

CONCLUSION

In Idaho, stalactiform blister rust is associated with stands dominated by lodgepole pine and located in cool, dry sites on mid to upper elevations throughout an elevational range of approximately 100^{o}m. In central Idaho, this range is approximately from 1500 m to 2400 m elevation, but we suggest this would be at higher elevations in southern latitudes and lower elevations in northern latitudes. Moisture and temperature interactions and elevation and stand compositions are conditions associated with stalactiform rust, whereas slope percent and aspect were non-descriptive of hazard stands. The rust occurred independently of many diseases and insect problems of lodgepole pine.

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