

Annotated Bibliography: WPBR Distribution

Prepared by Brian W. Geils on Wednesday, January 02, 2002

Allwine, K.J.; Bian, X.; Whiteman, C.D.; Thistle, H.W. 1997. VALDRIFT--A valley atmospheric dispersion model. *Journal of Applied Meteorology*. 36: 1076-1087.

Abstract: VALDRIFT (valley drift) is a valley atmospheric transport, diffusion, and deposition model...

Keywords: climate

Folder: WPBR distribution

Location: file

Baker, F.S. 1944. Mountain climates of the western United States. *Ecological Monographs*. 14:225-254.

Keywords: climate

Folder: WPBR distribution

Bega, R.V. 1960. The effect of environment on germination of sporidia in *Cronartium ribicola*. *Phytopathology*. 50:61-68.

Abstract: Sporidia of *Cronartium ribicola* were subjected to various environmental conditions to determine the effect of environment on germination. Type, time and vigor of germination were given primary emphasis because germination per se was found not to be an accurate measure of sporidial response to environment. Artificial light vs. dark was studied as to its effect on type and vigor of sporidial germination. No significant effect of light was noted. In laboratory studies, primary sporidia were capable of producing up to six successive generations of sporidia but the fourth to sixth generations appeared to be of minor importance in the disease spread. Secondary and tertiary sporidia, however, were produced in great enough abundance to warrant consideration. Indirect germination, therefore, is a means of vegetative perpetuation and can be an aid in dispersal and longevity of sporidia. A sporidium, with its ability to germinate either directly or indirectly, can act as an agent of infection or as an organ of sporulation. Germination of primary sporidia occurred over a range of pH from 3.0 to 1.0. The optimum pH was 3.0 for direct germination and 7.0-9.0 for indirect. It was inhibited at pH 2.0. The optimum pH for vigor of germination (length of germ tube) was at 4.0 and decreased with increase in pH. Secondary sporidia showed the same reactions. Germination occurred from 0.5-1 to 24 C at pH 6.8 and from 0.5-1 to 28 C at pH 4.0. Time was found to be an important factor in vigor of germination. At the higher temperatures sporidia exhibited greater vigor at pH 4.0 after 6 hours than at pH 6.8 after 24 hours. The influence of time-temperature-pH on direct vs. indirect germination was studied. Direct germination was favored at all temperatures studied at pH 4.0. Sporidia germinated on needles of *Pinus lambertiana* from 0.5-1 to 28 C. Vigor of germination was exemplified by the predominance of 2-3 germ tubes per spore and by branching of germ tubes. Germ tube length increased as the temperature increased to 16-20 C after which length decreased to 4.2 u at 28 C. Few secondary sporidia were formed on the needles at any of the temperatures studied. On needles of conifer species other than white pines indirect germination increased, and direct germination consisted predominantly of one germ tube per spore. No significant difference in vigor of germination was noted on needles of 6 species of white pine tested.

Annotation: Fig. 8 shows vigor of germination at different temperatures after 6 and 24 hours at pH 4.0 and 6.8. At both pH units optimum vigor was displayed at 16 C after 24 hours, but after only 6 hours the optimum at pH 4.0 was found to be 20 C. Figure 6 shows 100% germination at about 16 C after only 6 hours. The results presented here suggest that somewhat longer but warmer periods will ultimately give as much infection as a shorter, cooler period.

Keywords: white pine blister rust, epidemiology

Folder: cbr weather, WPBR distribution

Location: file, pathology

Bourke, P.M. Austin. 1965. The contribution of modern meteorology to plant disease forecasting. *Phytopathology*. 55: 943–942.

Annotation: Development of simple models of the relationship between meteorological conditions and a plant disease. Weather conditions play an important role in the seasonal development of many plant diseases. The first step toward using this relationship to forecast the disease is to express it in simple numerical terms. This may be done in either of two ways: (i) In the empirical approach, records of the impact of the disease over a number of seasons are compared with the corresponding meteorological data, and a relationship is extracted by statistical or other means. (ii) The experimental or laboratory approach to deriving models requires a prior knowledge of the range of atmospheric conditions that favor the pathogen. All models, however derived, have certain shortcomings. An insidious danger, of far wider occurrence than the present case, is gradually confusing the model with reality.

Keywords: epidemiology, weather, pest hazard

Folder: cbr weather, WPBR distribution

Location: file

Brown, D.H. 1967. White pine blister rust survey in Montana and Wyoming 1966. Mimeographed report August 1967. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region, State and Private Forestry. 11 p.

Annotation: White pine and Ribes were examined in the Shoshone, Bighorn, Medicine Bow, Gallatin, and Custer National Forest; Yellowstone National Park; and the Wind River Indian Reservation.

Keywords: white pine blister rust, damage survey, limb rust, Ribes

Folder: Ribes, WPBR distribution

Location: file

Brown, D.H. 1970. Recent discoveries extend distribution ranges of two destructive diseases of limber pine in southeastern Montana. *Plant Disease Reporter*. 54(5):441.

Annotation: White pine blister rust established in Wolf Mountains, Big Horn Mountains, and Pryor Mountains.

Keywords: limber pine, dwarf mistletoe, white pine blister rust, distribution

Folder: WPBR distribution

Location: file

Brown, D.H. 1978a. Extension of the known distribution of *Cronartium ribicola* and *Arceuthobium cyanocarpum* on limber pine in Wyoming. *Plant Disease Reporter*. 62:905.

Abstract: White pine blister rust and limber pine dwarf mistletoe are reported for the first time on limber pine in north central and southeastern Wyoming extending the known range of these diseases.

Keywords: limber pine, white pine blister rust, dwarf mistletoe, distribution

Folder: WPBR distribution

Location: file

Brown, D.H. 1978b. The status of white pine blister rust on limber pine and whitebark pine in Wyoming. *Tech. Rep. R2-13*. Lakewood, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Region. 10 p.

Annotation: This report describes the known distribution of the disease on pine throughout the state outside Yellowstone National Park.

Keywords: limber pine, whitebark pine, white pine blister rust, damage survey

Folder: WPBR distribution

Location: file, pathology

Brown, D.H.; Graham, D.A. 1969. White pine blister rust survey in Wyoming, Idaho and Utah, 1967. Mimeographed report. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region, State and Private Forestry. 9 p.

Annotation: A survey for white pine blister rust was conducted west of the Continental Divide in Wyoming, Idaho, and Utah in 1967.

Keywords: white pine blister rust, damage survey

Folder: WPBR distribution

Location: file

Brown, T.N.; White, M.A.; Host, G.E. 1999. Identification of risk factors for blister rust (*Cronartium ribicola*) on eastern white pine (*Pinus strobus* L.). Duluth: MN. University of Minnesota, Natural Resources Research Institute. 28 p.

Abstract: Mature white pine forest has been significantly reduced in northeastern Minnesota over the past 120 years. Blister rust, a usually lethal fungal disease of white pine, was also introduced about 120 (sic) years ago, and now poses a major challenge to attempts to reestablish white pines in the region. A map delineating hazard zones for blister rust was prepared in 1961--this report details the procedure used to update that map using modern GIS techniques. The new map is more detailed than the old, and recognizes that even within areas previously classified as "high hazard", there are places where white pine regeneration may be possible and desirable.

Keywords: white pine blister rust, eastern white pine, climate, map analysis

Folder: WPBR distribution

Location: file

Buchanan, T.S.; Kimmey, J.W. 1938. Initial tests of the distance of spread to and intensity of infection on *Pinus monticola* by *Cronartium ribicola* from *Ribes lacustre* and *R. viscosissimum*. *Journal of Agricultural Research*. 56(1):9-30.

Annotation: For the purpose of securing more definite data on the capacity of the prickly currant (*Ribes lacustre*) and the of the sticky currant (*R. viscosissimum*) to spread damaging white-pine blister rust infection to western white pine, so-called ribes-to-pine studies were initiated. Under the test conditions equal footages of live stem of the sticky currant and the prickly current are capable of spread essentially equal infection to nearby white pine reproduction. Both ribes species were capable of spreading appreciable infection to pines for a distance of at least 150 feet.

Keywords: *Ribes*, white pine blister rust, disease spread, epidemiology

Folder: *Ribes*, WPBR distribution

Location: pathology

Campbell, E.M.; Antos, J.A. 2000. Distribution and severity of white pine blister rust and mountain pine beetle on whitebark pine in British Columbia. *Canadian Journal of Forest Research*. 30(7):1051-1059.

Abstract: A major decline in the abundance of whitebark pine (*Pinus albicaulis* Engelm.) has recently occurred in the United States, primarily as result of white pine blister rust (*Cronartium ribicola* J.C. Fisch. ex Raben.). However, no information on the status of whitebark pine in British Columbia, Canada was available. We sampled 54 subalpine stands in British Columbia, examining all whitebark pine trees within plots for evidence of blister rust and mountain pine beetle (*Dendroctonus ponderosae* Hopk.) damage. About 21% of all whitebark pine stems were dead, and blister rust was the most important agent of mortality. Of all living trees sampled, 27% had obvious blister rust infection (cankers), but actual incidence was suspected of being as high as 44% (using all evidence of blister rust). Blister rust incidence and whitebark pine mortality were significantly related to differences in stand structure and the presence of *Ribes* spp., but relationships with local climate and site variables were absent or weak. Lack of strong relationships with climate suggests favorable conditions for spread of the disease throughout most of British Columbia. Very little evidence of mountain pine beetle was found. Overall, the prospects for whitebark pine in British Columbia do not appear good; a large reduction in population levels seems imminent.

Keywords: bark beetle, damage survey, whitebark pine, white pine blister rust

Folder: WPBR distribution, WPBR impact

Location: file

Catlin, T.; Frawley, D.; Kaney, L. 1994. Operationalizing the blister rust hazard index—one viewpoint. In: Interior cedar-hemlock-white pine forests: Ecology and management. Symposium proceedings. 1993, March 2-4; Spokane, WA. Pullman WA: Washington State University: 331-332.

Annotation: We used the recommendations contained in Hagle et al. (1989) and the personal computer (PC) program "Blister Rust Calculator" developed by McDonald and Rice at the Intermountain Research Station in Moscow, Idaho. We were not able at this time to build a reliable, predictive model for RI.

Good review of the process of determining and using RI.

Keywords: white pine blister rust, pest hazard

Folder: WPBR distribution

Location: file

Charlton, J.W. 1963. Relating climate to eastern white pine blister rust infection hazard. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Eastern Region. 38 p.

Annotation: Preliminary maps showing white pine blister rust hazard potentials for the Eastern United States were disappointing. Hazard (potential infection) was based on a limiting factor concept and mapped using data on climatic probabilities. Hazard zones were mapped for <40, 40–60, and >60 percent. Data ranges and factor functions were postulated, therefore results should be validated with field experience.

Keywords: eastern white pine, white pine blister rust, pest hazard, climate

Folder: cbr weather, WPBR distribution

Location: file, pathology

Chen, Mo-mei; Cobb, F.; Heald, R. 1985. White pine blister rust in young sugar pine plantations in the mid-elevation Sierra Nevada. *Phytopathology*. 75:1367.

Abstract: Sugar pine seedlings were included in mixed-species plantations on Blodgett Research Forest (av. elevation 1130 m) beginning in 1976. In 1983, the disease was detected on planted saplings, and a study was initiated in 1984. A total of 1277 saplings in 11 plantations and 476 scattered naturally-occurring saplings was examined; 16 percent of the planted saplings (1–53% of seedlings per individual plantation) and 12 percent of the natural saplings were infected. The years of origination of the infected internodes were determined: 60% of the infections were on 1981 tissue; 15% on 1982; 10% on 1980; 6% on 1979; and less than 1% on tissue of other years. Local weather data indicate that 1981 (with 11 days) and 1982 (with 6 days) were the only years since 1977 with more than one day of conditions favorable to infection. There was a strong correlation between infection and distance to *Ribes*. Both mature pycnia and aecia were detected during Fall, 1984. [complete text]

Keywords: sugar pine, white pine blister rust, epidemiology, pest hazard

Folder: cbr weather, WPBR distribution

Daly, C.; Neilson, R.P.; Phillips, D.L. 1994. A statistical-topographic model for mapping climatological precipitation over mountainous terrain. *Journal of Applied Meteorology*. 33:140--158.

Keywords: climate

Folder: WPBR distribution

Location: file

Davis, J.M.; Monahan, J.F. 1991. Climatology of air parcel trajectories related to the atmospheric transport of *Peronospora tabacina*. *Plant Disease*. 75:706–711.

Abstract: Five years of temperature and wind data from atmospheric soundings were used in conjunction with the U.S. National Oceanic & Atmospheric Administration (NOAA) Air Resources Laboratories Atmospheric Transport and Dispersion (ATAD) model to construct an atmospheric air parcel trajectory climatology for the transport of the sporangiospores of the fungus *Peronospora tabacina*. With the receptor point in the North Carolina mountains, four receptor-oriented (backward-in-time) trajectories were calculated daily for April through August, as well as for the annual period. The 12-, 24-, and 48-hr air parcel positions, before the arrival of the air parcel in the mountains, were plotted. These spatial data were used in a nonparametric density estimation routine that generated plots of probability density function contours for the 12-, 24-, and 48-hr periods. Numerical integration was used to obtain probabilities from the contours of the probability density function. These analyses should be useful in assessing the probability that the specified location in western North Carolina received air parcels from various geographical locations; however, only those air parcels that come from regions where a source of diseased tobacco plants is present would be of epidemiological significance.

Keywords: epidemiology, dispersal gradient, spatial analysis

Folder: WPBR distribution

Denitto, G.A. 1987. Incidence and effects of white pine blister rust in plantations with sugar pine in the northern and central Sierra Nevada, California. In: *Proceedings 35th Annual WIFDWC*: 24–28.

Abstract: Twenty-nine plantations in northern and central Sierra Nevada were surveyed for blister rust incidence. One plantation was uninfested, whereas other stands, 4 to 26 years of age, possessed infection levels ranging from 44 to 93% with an average of 64%. Rust has reduced stocking to below acceptable levels in one stand (28% of total) and is projected to reduce stocking in four more plantations (41% of total). In three other plantations some sugar pine must survive or stocking levels will not be acceptable. No relationship between blister rust incidence and estimated site hazard was found. Adequately stocked stands can best be assured by not relying on survival of sugar pine, or by planting resistant sugar pine.

Annotation: White pine blister rust is a major limiting factor in growing sugar pine in the northern and southern Sierra Nevada. Surveys [in southern Sierras] suggest a large increasing infection over a 15 year period...it does not appear that the rate of infected has stabilized.

Keywords: sugar pine, white pine blister rust, damage survey

Folder: WPBR distribution

Location: file

Dorroh, J.H., Jr. 1945. Certain hydrological and climatic characteristics of the Southwestern Region. *Regional Bulletin 98 #3548, Engineering Series 9*. Albuquerque, NM: U.S. Department of Agriculture, Soil Conservation Service, Region 6.

Annotation: Air mass movements, storm types, quantity and distribution of precipitation, intensity characteristics, other climatic characteristics, summer of climatic factors. Includes figures of normal air mass movements and distribution of precipitation for AZ, UT, CO and NM.

Keywords: climate

Folder: WPBR distribution

Location: file

Draper, M.A.; Walla, J.A. 1993. First report of *Cronartium ribicola* in North Dakota. *Plant Disease*. 77:952.

Abstract: In mid-May 1992, a sample of an upper branch of limber pine (*Pinus flexilis* E. James), the only five-needle pine native to North Dakota, was submitted to the Plant-Pest Diagnostic Laboratory at North Dakota State University. The branch displayed on 1988 wood a sporulating aecial canker typical of those produced by *Cronartium ribicola* J. C. Fisch., the causal agent of white pine blister rust. Confirmation of *C. ribicola* was based on the characteristic orange aeciospores, mostly short-ellipsoid, 19x22 μ m, with coarsely verrucose walls and a conspicuous smooth spot. The 30-yr-old tree had been planted as a seedling on a site in urban Morton County, near the center of the state. When examined in June 1992, the tree bore no branch or stem cankers; however the homeowner had removed upper branches with rust symptoms in recent years. Nearby *Ribes* spp. (alternate hosts) and adjacent eastern white pine (*P. strobus* L.) did not show symptoms of infection. Surveys in North Dakota in 1992 and in previous years of planted stands of eastern white pine and native stands of limber pine did not detect *C. ribicola*. The nearest known occurrences of *C. ribicola* are in northwestern Minnesota and the Black Hills of South Dakota. This sample represents a substantially reduced separation between known *C. ribicola* populations in eastern and western North America. The specimen is retained by J. A. Walla. [complete article]

Keywords: limber pine, distribution, white pine blister rust
Folder: WPBR distribution

Et-touil, K.; Bernier, L.; Beaulieu, J.; Berube, J.A.; Hopkin, A.; Hamelin, R.C. 1999. Genetic structure of *Cronartium ribicola* populations in eastern Canada. *Phytopathology*. 89(10):915–919.

Abstract: The genetic structure of populations of *Cronartium ribicola* was studied by sampling nine populations from five provinces in eastern Canada and generating DNA profiles using nine random amplified polymorphic DNA markers. ...Yet, genetic differentiation among populations within regions or provinces was small but statistically significant and was several orders of magnitude larger than differentiation among provinces. This is consistent with a scenario of subpopulations within a metapopulation, in which random drift following migration and new colonization are major evolutionary forces. A phenetic analysis using genetic distances revealed no apparent correlation between genetic distance and the province of origin of the populations. The hypothesis of isolation-by-distance in the eastern populations of *C. ribicola* was rejected. These results show that eastern Canadian provinces are part of the same white pine blister rust epidemiological unit. ...Long-distance spore dispersal across province boundaries appears to be an epidemiologically important factor for this pathogen.

Keywords: biogeography, eastern white pine, population genetics, white pine blister rust
Folder: WPBR distribution Location: file, pathology

Fracker, S.B. 1936. Progressive intensification of uncontrolled plant-disease outbreaks. *Journal of Economic Entomology*. 29:923–940.

Annotation: [from summary]...white pine blister rust follows the same general type of development as that of human population and that there are several convenient ways in which it can be measured: first, the rate of increase may be represented by the m in the logistic curve used in studies of human population; second, the extent of the gradual suppression of the increase in the *Ribes* population, the most important factor in the environment from the blister rust standpoint, can be determined by introducing appropriate coefficients to represent acceleration in the same population equation; and third, the effect of the distribution of the *Ribes* in a given environment can be measured by finding out how many more cankers are present per tree in the stand, in view of the percentage of infected trees, than would be there if the *Ribes* were scattered uniformly among the trees.

Keywords: white pine blister rust, epidemiology, spatial analysis
Folder: WPBR distribution Location: file

Geils, B.W. 2000. Establishment of white pine blister rust in New Mexico. In: Ribes, Pines, and White Pine Blister Rust. Corvallis: OR. 8–10 September 1999. HortTechnology. 10(3):528–529.

Annotation: White pine blister rust is a recently established pathogen of southwestern white pine and Ribes in New Mexico.

Keywords: white pine blister rust, white pine, Ribes

Folder: WPBR distribution

Location: shelf, reprint

Geils, B.W.; Conklin, D.A.; Van Arsdel, E.P. 1999. A preliminary hazard model of white pine blister rust for the Sacramento Ranger District, Lincoln National Forest. Res. Note RMRS-RN-6. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 6 p.

Abstract: Blister rust, caused by the introduced fungus *Cronartium ribicola*, is a serious disease of white pines in North America. Since about 1970, an outbreak has been increasing in the Sacramento Mountains of southern New Mexico and threatens southwestern white pine. As part of an effort to determine the expected extent and impact of blister rust, we propose a preliminary hazard model for the Sacramento Ranger District. The model is based on field observations and experience. We assume blister rust incidence and severity on white pine varies with microclimate and proximity to telial hosts (certain species of Ribes). We identify the sites at risk and rank them into three relative hazard classes based on elevation, plant association, and topographic position. Information is currently available to provisionally identify hazard for blister rust on 35% of the district area at risk. Of the area rated, 12% is low hazard, 43% is moderate hazard, and 45% is high hazard. Average rust incidence level for plots rated as low, moderate, or high hazard was 6%, 45%, and 47%, respectively; average severity was 0.1, 2.5, and 4.5 cankers per tree. Studies are underway to test and refine the model.

Keywords: disease spread, distribution, GIS, pest hazard, Ribes, SW white pine, white pine blister rust

Folder: WPBR distribution

Location: reprint

Goddard, R.E.; McDonald, G.I.; Steinhoff, R.J. 1985. Measurement of field resistance, rust hazard, and deployment of blister rust-resistant western white pine. Res. Pap. INT-358. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 8 p.

Abstract: Annual rates of infection and mortality caused by *Cronartium ribicola* were studied in 3 *Pinus monticola* plantations established near Clarkia, Idaho, during 1955–59, using material with varying resistance from early generations of blister rust resistance breeding program. The sites varied in *C. ribicola* hazard, but resistant materials were consistent in their performance. A simple interest model of disease progress provided a reasonably accurate prediction of future infection of susceptible classes.

Keywords: western white pine, white pine blister rust, damage to host, epidemiology, host resistance, pest hazard

Folder: WPBR distribution

Location: pathology

Gross, H.L. 1985. White pine blister rust: a discussion fo the disease and hazard zones for Ontario. Proc. Ent. Soc. Ont. Suppl. 116:73–79.

Abstract: Infection hazard zones for the white pine blister rust disease caused by *Cronartium ribicola* J.C. Fisch. are presented for Ontario. Interpretation of climatological, topographic, and physiographic data is based on methods used previously in the Lake States to rate infection hazard. Survey data on intensity of infection in the various hazard zones indicate that the methods work for Ontario. Other aspects of blister rust control are discussed. Pruning of the highly susceptibel branches on the lower part of the tree is promoted as a method for providing good control of the disease.

Annotation: Missing even-numbered pages.

Keywords: eastern white pine, epidemiology, white pine blister rust

Folder: WPBR distribution

Location: file

Hamelin, R.C.; Hunt, R.S.; Geils, B.W.; Jenson, G.D.; Jacobi, V.; Lecours, N. 2000. Barrier to gene flow between eastern and western populations of *Cronartium ribicola* in North America. *Phytopathology*. 90:1073–1078.

Abstract: The population structure of *Cronartium ribicola* from eastern and western North America was studied to test the null hypothesis that populations are panmictic across the continent. Random amplified polymorphic DNA markers previously characterized in eastern populations were mostly fixed in western populations, yielding high levels of genetic differentiation between eastern and western populations. An unweighted pair-group method, arithmetic mean dendrogram based on genetic distances separated the four eastern and four western populations into two distinct clusters along geographic lines. Similarly, a principal components analysis using marker frequency yielded one cluster of eastern populations and a second cluster of western populations. The population from New Mexico was clearly within the western cluster in both analyses, confirming the western origin of this recent introduction. The population was completely fixed at all loci suggesting a severe recent population bottleneck. Genetic distances were low among populations of western North America and among eastern populations, indicating a very similar genetic composition. In contrast genetic distances between eastern and western populations were large, and all were significantly different from 0. Indirect estimates of migration among pairs of populations between New Mexico and British Columbia populations, but were smaller than one migrant per generation between eastern and western populations. These results suggest the presence of a barrier to gene flow between *C. ribicola* populations from eastern and western North America.

Keywords: biogeography, epidemiology, population genetics, white pine blister rust

Folder: WPBR distribution

Location: file

Harris, J.L. 1999a. Evaluation of white pine blister rust disease on the Shoshone National Forest. Biological Evaluation R2-99-05. Golden, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Region, Renewable Resources. 11 p.

Abstract: White pine blister rust is a disease that is severely impacting many whitebark and limber pine stands of the northern Rocky Mountains. Whitebark pine has been described as a "keystone" species and its seed is used by several animals, especially by grizzlies, as a source for fat and protein. Limber pine has little timber market value, yet is an important tree species for biodiversity purposes. The disease was introduced to western North America and found in Yellowstone National Park in 1945. Region 2 Forest Health Management conducted a survey for the disease on the Shoshone National Forest and then later installed 13 permanent plots for long term monitoring of the sites. Low incidence levels of the disease were found during the survey. However, two areas of moderate to high infection levels were found. Tree data and rust damages were recorded during the survey and permanent plot installations. Data on *Ribes* species, the alternate host for the disease, and on pine regeneration were also noted on the permanent plots. Counts of the rust infections were made for each site. Less than 15% incidence levels of white pine blister rust disease were found on the Shoshone National Forest and in eastern Yellowstone National Park. Two sites on the Shoshone National Forest were classified with high disease levels of greater than 50% infection in host trees. Recommendations are to find whitebark pine trees resistant to the disease and promote their habitat and seed protection. Forest Health Management should continue to monitor the permanent plots.

Keywords: damage survey, white pine, white pine blister rust, whitebark pine

Folder: *Ribes*, WPBR distribution

Location: file

Harris, J.L. 1999b. White pine blister rust disease of limber pine in the Bighorn and Medicine Bow National Forests. Biological Evaluation R2000-02. Golden CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Region, Renewable Resources.

Abstract: White pine blister rust has been found at low to moderate infection levels in several limber pine stands of the Bighorn and Medicine Bow National Forests. ...

Keywords: damage survey, limber pine, white pine blister rust

Folder: WPBR distribution

Location: file

Harvey, G.M. 1967. Growth and survival probability of blister rust cankers on sugar pine branches. Res. Note PNW-54. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 6 p.

Annotation: Study made to determine proximal growth rate of cankers and survival probability of cankers based on distance from trunk. Growth dependent on branch diameter : $y=0.7+0.5x$, $r=.16$, y = proximal growth as inches per year, x = branch diameter as inches. Rate on sugar pine 1.7 time less than on western white. Probit transformation used to derive survival function. Canker survival lower on sugar than western.

Keywords: sugar pine, white pine blister rust, canker dynamics

Folder: WPBR distribution

Location: file, reprint

Harvey, G.M.; Cohen, L.I. 1958. The extent of blister rust mycelia beyond bark discolorations of sugar pine. Res. Note PNW-159. Portland, OR: U.S. Department of Agriculture, Forest Service, 4 p.

Annotation: Ninety-nine cankers were examined for proximal extent of mycelia beyond discoloration. Mean extent was 2 inches, maximum 5 inches for spring collections; 1 inch mean and 2 inch maximum for summer collections.

Keywords: sugar pine, white pine blister rust, canker dynamics

Folder: WPBR distribution

Location: file

Hoff, R.J. 1992b. How to recognize blister rust infection on whitebark pine. Res. Note INT-406. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 7 p.

Abstract: Color photographs show how white pine blister rust can be identified. In addition, the photographs show how pines resistant to the fungus could be identified. Such trees could be used to develop a new variety of whitebark pine that is resistant to blister rust.

Keywords: whitebark pine, white pine blister rust, id guide

Folder: WPBR distribution

Location: file

Hummer, K.E. 2000. History of the origin and dispersal of white pine blister rust. HortTechnology. 10:515-517.

Keywords: white pine blister rust

Folder: WPBR distribution

Location: shelf

Hungerford, R.D.; Nemani, R.R. Running, S.W.; Coughlan, J.C. 1989. MTCLIM: a mountain microclimate simulation model. Res. Pap. INT-414. Ogden UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 52 p.

Abstract: A model for calculating daily microclimate conditions in mountainous terrain is presented. Daily air temperature, short-wave radiation, relative humidity, and precipitation are extrapolated from data measured at National Weather Service stations. The model equations are given and the paper describes how to execute the model. Model outputs are compared with observed data from several mountain sites.

Keywords: climate

Folder: WPBR distribution

Location: shelf

Kinloch, B.B. Jr.; Dulitz, D. 1990. White pine blister rust at Mountain Home Demonstration State Forest: a case study of the epidemic and prospects for genetic control. Res. Pap. PSW-204. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 7 p.

Abstract: The behavior of white pine blister rust at Mountain Home State Demonstration Forest and surrounding areas in the southern Sierra Nevada of California indicates that the epidemic has not yet stabilized and that the most likely prognosis is a pandemic on white pines in this region within the next few decades. The impact on sugar pines, from young regeneration to old growth, already has been severe in some areas, and silvicultural control measures have been largely ineffective. An operational genetic program, based on selection of seed parents carrying a major resistance gene, is described that is simple and effective. This program will be useful in maintaining sugar pine as a crop species in artificial regeneration for at least one rotation, and in preserving the genetic integrity of sugar pine populations in jeopardy from the rust.

Keywords: sugar pine, white pine blister rust, genetics program

Folder: WPBR distribution

Location: file

Kliejunas, J. 1982a. A biological evaluation of white pine blister rust on portions of the Covelo Ranger District, Mendocino National Forest. Rep. 82-29. San Francisco, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, State and Private Forestry. 5 p.

Keywords: white pine blister rust, damage survey

Folder: WPBR distribution

Kliejunas, J. 1982b. A biological evaluation of white pine blister rust on the Sierra National Forest. Rep. 82-44. San Francisco, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, State and Private Forestry. 19 p.

Keywords: white pine blister rust, damage survey

Folder: WPBR distribution

Kliejunas, J. 1984. A biological evaluation of white pine blister rust on the Sequoia National Forest. Rep. 84-22. San Francisco, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, State and Private Forestry. 26 p.

Keywords: white pine blister rust, damage survey

Folder: WPBR distribution

Kliejunas, J. 1985. Spread and intensification of white pine blister rust in the southern Sierra Nevada. *Phytopathology*. 75:1367.

Abstract: White pine blister rust (*Cronartium ribicola*) entered northern California in 1929 and advanced southward on sugar pine (*Pinus lambertiana*) to the central Sierra Nevada by 1944. Surveys in 1971–72 found that the rust had spread south in the 1960's to isolated centers 150 miles further south. Incidence and impact surveys on the Sierra and Sequoia National Forests in 1982–83 found rust at 22 unreported locations and at the southern extent of sugar pine in the Sierra Nevada. Rust was adversely impacting the resource in local situations where significant spread and intensification had occurred since 1972. Canker incidence generally decreased from stream bottom to upper slope, but the disease was also found on ridge tops. Cankers in lower branches of smaller trees were most common. The southern Sierra Nevada climate is favorable for infection most years and local spread and intensification will continue. [complete]

Keywords: white pine blister rust, biogeography, pest hazard, pest impact

Folder: WPBR distribution

Kliejunas, J. 1996. An update of blister rust incidence on the Sequoia National Forest. Rep. R96-01. San Francisco, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, State and Private Forestry.

Keywords: white pine blister rust

Folder: WPBR distribution

Krebill, R.G. 1964. Blister rust found on limber pine in northern Wasatch Mountains. Plant Disease Reporter. 48:532.

Annotation: In July of 1963 two limber pines with several well-developed rust cankers were found in Skinner Canyon in the Cache National Forest.

Keywords: limber pine, white pine blister rust, distribution

Folder: WPBR distribution

Location: file, pathology

Lachmund, H.G. 1933a. Mode of entrance and periods in the life cycle of Cronartium ribicola on Pinus monticola. Journal of Agricultural Research. 47:791–805.

Annotation: Infection is through needles. Incubation, period from infection to appearance on bark, lasts 2 to 4 yr. After incubation, pycniospore production requires 1 to 10 months; then aeciospore production requires 0.5 to 2.5 yr and continues for about 1 to 5 yr.

Keywords: white pine blister rust, epidemiology, phenology

Folder: cbr weather, WPBR distribution

Location: file, pathology

Lachmund, H.G. 1933b. Method of determining age of blister rust infection on western white pine. Journal of Agricultural Research. 46:675–693.

Annotation: Western white pine in the Pacific Northwest cast most of the needles of any one year at the end of the fourth season, although some are held longer (up to about 8). Rust infection may enter the bark on internodes up to 8 season of age, but is chiefly on the last 4 internodes. Conditions favorable for heavy infection in the Pacific Northwest occur about one season in three. Heavy infection in any year is manifested as cankers distributed: few on the growth of the season or on growth older than 3 years and most on 1 and 2 year-old growth.

Keywords: western white pine, white pine blister rust, epidemiology

Folder: WPBR distribution

Location: file

Lavallee, A. 1985. Zones de vulnerabilite du pin blanc a la rouille vesicul euse au Quebec. Forestry Chronicle. 62:24–28. [in French]

Abstract: Analysis of relevant data for the last 11 years improved the precision of zoning for white pine vulnerability to blister rust in Quebec. The validity of the existing approach for the area under study was confirmed. White pine located in zones 1 and 2 usually indicated less than 15% stem infections by the blister rust. Distribution of white pine weevil damage in the zones is presented.

Keywords: eastern white pine, epidemiology, white pine blister rust

Folder: WPBR distribution

Location: file

Lundquist, J.E. 1993. Large scale spatial patterns of conifer diseases in the Bighorn Mountains, Wyoming. Res. Note RM-523. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p.

Abstract: A roadside reconnaissance for forest diseases in the Bighorn National Forest was conducted in 1991. The most common disorders were dwarf mistletoe, Comandra blister rust, western gall rust, and an undetermined needlecast of lodgepole pine; broom rusts, patch mortality, branch canker and crown mortality of Engelmann spruce and subalpine fir; and white pine blister rust of limber pine. The most widespread disorders showed the greatest diversity across the forest. Two or more disorders (average=4) occurred concurrently on all townships.

Keywords: biogeography, map analysis, dwarf mistletoe, Comandra blister rust, western gall rust, white pine rust

Folder: WPBR distribution

Location: file

Lundquist, J.E.; Geils, B.W.; Johnson, D.W. 1992. White pine blister rust on limber pine in South Dakota. Plant Disease. 76:538.

Abstract: White pine blister rust, caused by *Cronartium ribicola* J. C. Fisch., here reported for the first time from South Dakota, was found on limber pine (*Pinus flexilis* E. James) and wax current (*Ribes cereum* Douglas) in a 2.5-ha stand at Cathedral Spires in the Black Hills National Forest. The infected stand is the easternmost natural extension of limber pine and is isolated from the nearest limber pine stand by 160 km and the nearest known population of *C. ribicola* by 240 km. Diseased pines bore dying branches with fusiform swellings and ruptured bark associated with aecial. Aeciospores match previous descriptions of *C. ribicola* when stained with lactophenol and cotton blue and viewed under a microscope. Aecia or uredinia were found on about 10% of the host trees or shrubs, respectively. Voucher specimens have been deposited in the Forest Service Forest Pathology Herbarium, Fort Collins, Colorado (No 6805-C).

Annotation: entire publication

Keywords: limber pine, stem rust, distribution, white pine blister rust

Folder: WPBR distribution

Location: reprint

McCubbin, W.A. 1918. Dispersal distance of urediospores of *Cronartium ribicola* as indicated by their rate of fall in still air. Phytopathology. 8:35–36.

Keywords: disease spread, epidemiology

Folder: WPBR distribution

McDonald, G.I. 1996. Ecotypes of blister rust and management of sugar pine in California. In: Kinloch, B.B., Jr.; Morosy, M.; Huddleston, M.E., eds. Sugar Pine: Status, values, and roles in ecosystems: Proceedings of a symposium presented by the California Sugar Pine Management Committee. Publication 3362. Davis CA: University of California, Division of Agriculture and Natural Resources:

Abstract: Comparison of weather records from the southern Sierra Nevada and northern Idaho and other evidence demonstrated that the southern Sierra Nevada climate was potentially unsuited for a northern ecotype of blister rust. A north Idaho ecotype, characterized by actual spore germination data, and several theoretical southern Sierra Nevada ecotypes were "subjected" to the two environments in a simulation model of rust epidemics. Output showed the Idaho ecotype incapable of basidiospore production in the southern Sierra Nevada, but indicated that a hypothesized southern Sierra Nevada ecotype adapted or acclimated to cooler infection-period temperatures and shorter growing seasons could have infected local sugar pines by mid-June. Observed high levels of rust damage in the southern Sierra Nevada may be explained by the appearance of the new rust ecotype. Comparing spore germination response over temperature gradients for actual genotypes from the southern, central, and northern Sierra Nevada and north Idaho would constitute a powerful test of the hypothesis.

Keywords: white pine blister rust

Folder: WPBR distribution

Location: file

McDonald, G.I.; Geils, B.W.; Scriptor, S. 1990. Integration of GIS and ecosystem process models: Site-specific mapping of rust hazard. In: Proceedings of IUFRO 19th World Congress, August 5–11, 1990, Montreal, Canada: 205. [abstract]

Abstract: White pine blister rust is a major problem in white pine forests of North America. Rust Hazard is conditioned by topographic, climatic, and vegetational aspects of individual sites. Ecological and microclimatological models could meld site-specific attributes into a hazard expectation for small geographic units (i.e., 0.5 hectare cells). Unit attributes of Ribes density, Ribes distribution pattern, stand basal area, white pine site index, leaf area index, precipitation isohyet, albedo, elevation, slope, aspect, east horizon, and west horizon would be needed to initialize existing models. A base weather station of known latitude, elevation, and annual precipitation record must supply daily maximum temperature, minimum temperature, and precipitation. Daily output from the climate model could simulate occurrence and duration of Ribes and pine infection periods. Annual estimated amount of rust infection, expressed as cankers / 1 000 needles/year and averaged over 10 years, could be mapped by 0.5 hectare cells to provide information supporting integrated management of white pine blister rust. Remote sensing of topographic and vegetational data to initialize the models has potential to enable economical creation of blister rust hazard maps for stands, drainage, or larger management units. After appropriate calibration, the technique could supply maps depicting hazard to any pine rust. These ideas were tested by creation of a blister rust hazard map for the Priest River Experimental Forest located in northern Idaho, USA. Remotely sensed topographic and vegetation data were obtained, placed in a GIS environment, and coupled to blister rust epidemic models. Mapped hazard was then compared to hazard previously determined on four small plantations. [complete article]

Annotation: Presentation by McDonald at IUFRO 19th World Congress, August 5-11, 1990, Montreal, Canada.
Keywords: white pine blister rust, pest model, spatial model, GIS, FVS, ecosystem model
Folder: WPBR distribution Location: reprint

McDonald, G.I.; Hoff, R.J. 2001. Blister rust: An introduced plague. In. Tomback, D.F.; S.F. Arno; and R.E. Keans, eds. Whitebark pine communities: ecology and restoration. Washington, DC: Island Press.
Folder: WPBR distribution, WPBR impact

McDonald, G.I.; Hoff, R.J.; Wykoff, W. 1981. Computer simulation of white pine blister rust epidemics. I. Model formulation. Res. Pap. INT-258. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 136 p.

Abstract: A simulation model of white pine blister rust is described in both word and mathematical models. The objective of this first generation simulation was to organize and analyze the available epidemiological knowledge to produce a foundation for integrated management of this destructive rust of 5-needle pines. Verification procedures and additional research needs are also discussed.

Keywords: white pine blister rust, epidemiology, pest model
Folder: WPBR distribution Location: shelf

Mielke, J.L. 1943. White pine blister rust in western North America. School of Forestry Bulletin. 52. New Haven, CN: Yale Univ. 155 p.

Annotation: Origin of white pine blister rust. Introduction to North America. White pine of western North America. the rust on pine. The rust on ribes. Scouting for the rust. Early history of blister rust in the west. Spread of the rust by years (1910–1942). General aspect of spread. Disseminating agencies and spore stage involved. Possible limits of long-distance spread. Relation of weather to spread and intensification of the rust. Wavelike character of spread of the rust. Rate and direction of spread of the rust. Some relations of ribes species in the spread of the rust. Pinyon rust: its complication in spread of blister rust. Some biological factors unfavorable to development of the rust. Strains of white pine blister rust.

Keywords: western white pine, white pine blister rust, review
Folder: WPBR impact, Ribes, WPBR distribution Location: shelf

Miller, D.R. 1967. Factors used in the field when differentiating between white pine blister rust (*Cronartium ribicola*) and pinyon rust (*Cronartium occidentale*) growing on the leaves of Sierra gooseberry (*Ribes roezli*). White Pine Blister Rust Control 5270. San Francisco, CA: U.S. Department of Agriculture, Forest Service, Division Timber Management.

Annotation: White pine blister rust and pinyon rust are "look-alikes" when growing on the leaves of their *Ribes* host. The identifying characteristics of the two rust as found on *R. roezli* are not always applicable when they occur on other species of *Ribes*. Kimmey listed five characters: telial column of pinyon rust dense, even fur-like; mature but un-geminated telia of pinyon rust darker brown than white pine rust (if not germinated, both becoming dark with age); after germination, columns of pinyon rust fade to a lavender hue; white pine rust more frequently fails to produce telia after producing uredinia; and if infection is light, white pine rust produces few, scattered spots whereas spots produced by pinyon rust enlarge with expanding margins. Hardman developed a key base on presence, severity, morphology, and extent of necrosis. In other observations of species also found in Sacramento Mountains of New Mexico, *R. cereum* was observed to highly resistant to both species and *R. inermis* varied considerably in susceptibility.

Keywords: white pine blister rust, pinyon blister rust, id guide, *Ribes*
Folder: *Ribes*, WPBR distribution Location: file

Miller, D.R. 1968. White pine blister rust found on foxtail pine in northwestern California. Plant Disease Reporter. 52:391.

Abstract: In September 1967, white pine blister rust was found, for the first time, infecting trees of foxtail pine in a native stand. The infected trees growing at an elevation of about 6,000 feet were on Marble Mountain, in Siskiyou County, California.

Keywords: foxtail pine, white pine blister rust, host range, distribution
Folder: WPBR distribution Location: file

Mitchell, V.L. 1976. The regionalization of climate in the western United States. Journal of Applied Meteorology. 15:920-927.

Abstract: The western United States is divided into climatic regions based on the air masses that predominate during the summer and winter. Equivalent potential temperature, chosen because it apparently best reduces the effect of elevation on air masses, is the parameter used to determine the locations of mean air mass boundaries during each month of the year. The climatic regions defined aid in understanding the causes of the climates of the West.

Keywords: climate
Folder: WPBR distribution Location: file

Neilson, R.P. 1987. Biotic regionalization and climatic controls in western North America. Vegetatio. 70:135-147.

Abstract: New methods of weather analysis accompanied by microhabitat 'bioassays' have been applied in several case studies to demonstrate effects of atmospheric processes on patterns of community composition and structure and potential species evolution... The two methods of weather analysis have been combined in a regional assessment of climatic controls of different biomes in space and time with a primary focus on the Chihuahuan desert...

Annotation: Includes as Figure 1 a map of the North American Southwest and beyond (northwest Mexico, CA and east to TX and SD) with extent of Arizona Monsoon gradient from sw AZ through se UT and nw CO to se WY.

Keywords: climate
Folder: WPBR distribution Location: file

Neilson, R.P. 1993. Transient ecotone response to climatic change: Some conceptual and modelling approaches. *Ecological Applications*. 3(3):385–395.

Abstract: Accurate prediction of the ecological impacts of climatic change is a pressing challenge to the science of ecology. The current state of the art for broad scale estimates of change in biomes and ecotones between biomes is limited to equilibrium estimates of ecological change under some future equilibrium climate...Ecologists and policymakers need to go beyond equilibrium estimates of biosphere change to transient responses of the biosphere as the climate changes...Ecotones between biomes have been suggested as sensitive areas of change that could be effectively modelled and monitored for future change...

Keywords: climate

Folder: WPBR distribution

Location: file

Neilson, R.P.; King, G.A.; DeVelice, R.L.; Lenihan, J.M. n.d. Regional and local vegetation patterns: the responses of vegetation diversity to subcontinental air masses. In: Hansen, A.J.; di Castri, F., eds. *Landscape Boundaries*. Springer-Verlag: 129–147.

Annotation: Effects of climate on biome boundaries, regional climatic gradients and local habitat scaling, habitat scaling and species interactions, habitat variability through time, time and space scale of organisms, patterns and constraints.

Keywords: climate

Folder: WPBR distribution

Location: file

O'Neill, R.V.; Gardner, R.H.; Turner, M.G.; Romme, W.H. 1992. Epidemiology theory and disturbance spread on landscapes. *Landscape Ecology*. 7(1):19–26.

Abstract: Epidemiology models, modified to include landscape pattern, are used to examine the relative importance of landscape geometry and disturbance dynamics in determining the spatial extent of a disturbance, such as a fire. The models indicate that, except for very small values for the probability of spread, a disturbance tends to propagate to all susceptible sites that can be reached. Therefore, spatial pattern, rather than disturbance dynamics, will ordinarily determine the total extent of a single disturbance event. The models also indicate that a single disturbance will seldom become endemic, i.e., always present on the landscape. However, increasing disturbance frequency can lead to a landscape in which the proportion of susceptible, disturbed, and recovering sites are relatively constant.

Keywords: epidemiology, disturbance, fire ecology

Folder: disturbance, WPBR distribution

Location: file

Quick, C.R. 1962. Relation of canyon physiography to the incidence of blister rust in the central Sierra Nevada. Tech. Pap. 67. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station.

Abstract: White pine blister rust is widespread and abundant on sugar pine in northwestern California. In the central Sierra Nevada, it tends to occur in pockets in canyons and stream basins. Records of infection near the southerly limit of the disease were scrutinized. Data from 14 areas were studied statistically. Eight physiographic factors were computed for each center. Canyon physiography and intensity of rust were markedly related. A records approach to prediction of future rust incidence in the central Sierra Nevada could be useful in planning control work.

Keywords: disease spread, landform, spatial analysis, sugar pine, weather, white pine blister rust, wind

Folder: WPBR distribution

Location: file, pathology

Robbins, K.; Jackson, W.A.; McRoberts, R.E. 1988. White pine blister rust in the eastern Upper Peninsula of Michigan. Northern Journal of Applied Forestry. 5:263–264.

Abstract: Incidence of blister rust, caused by *Cronartium ribicola*, found during a survey of eastern white pines on the Hiawatha National Forest in the eastern Upper Peninsula of Michigan was unexpectedly low: only 6.8% of all plots had one or more infected white pine and 1.5% of all white pines surveyed had blister rust.

Annotation: Questions the validity of local site factors and geographic hazard zones for adequately assessing disease risk in this area.

Keywords: eastern white pine, white pine blister rust, damage survey, pest hazard

Folder: WPBR distribution

Location: file

Running, S.W.; Nemani, R.R.; Hungerford, R.D. 1987. Extrapolation of synoptic meteorological data in mountainous terrain and its use for simulating forest evapotranspiration and photosynthesis. Canadian Journal of Forest Research. 17:472-483.

Keywords: climate

Folder: WPBR distribution

Rust, M. 1988. White pine blister rust hazard rating: an expert systems approach. AI Applications in Natural Resource Management. 2:47–50.

Annotation: A prototype expert system is described that uses site factors known to influence the suitability of a habitat for *Ribes* germination and growth to predict blister rust (*Cronartium ribicola*) hazard rating. Once the rating is determined, the system provides a recommendation of the suitability of planting white pine (*Pinus monticola*) on the site and the recommended rust resistance of the planting stock. The system was designed for foresters regenerating white pine sites in Idaho.

Keywords: white pine blister rust, pest hazard, AI/DSS

Folder: WPBR distribution

Location: file

Smith, J.; Hoffman, J. 1998. Status of white pine blister rust in Intermountain Region white pines. Report R4-98-02. Boise, ID: U.S. Department of Agriculture, Forest Service, Intermountain Region, State and Private Forestry, Forest Health Protection.

Abstract: Recent investigations have documented high levels of white pine blister rust (WPBR) in the whitebark pine and limber pine of the Rocky Mountain Region. However, in the Intermountain Region, little is known about the disease which occurs on whitebark, limber, western white, sugar, and potentially bristlecone pines. We formally surveyed white pines at 100 sites, and collected incidental sample data at an additional 27 sites within the Intermountain Region. Objectives were to investigate WPBR incidence, intensity, damage, mortality, and spread. Overall incidence of WPBR was 59% across the entire region, but varied substantially between national forests, and sample locations. Intensity within infected stands averaged 36% and ranges from 2% to 100%. Incidence and intensity appear to have increased dramatically in the northern portion of the Intermountain Region over the past 30 years, but the southward spread of the disease has slowed, and does not appear to be an immediate threat to Great Basin white pines. We found no evidence of a corridor of infected white pines between the Northern Rocky Mountains or Sierra Nevada and a satellite infection on the Lincoln National Forest in New Mexico. Smaller diameter trees suffered top kill and mortality more frequently than larger diameter trees. Only 34 of approximately 5000 trees inspected appeared to have died as a result of white pine blister rust infection, but mortality is expected to increase sharply in portions of the Intermountain Region as cankers from recent infections reach main tree stems.

Keywords: white pine blister rust, bristlecone pine, damage survey, disease spread, distribution, western white pine, whitebark pine, limber pine

Folder: WPBR distribution

Location: file

Smith, J.P.; Hoffman, J.T. 2000. Status of white pine blister rust in the Intermountain West. Western North American Naturalist. 60(2):165–179.

Abstract: During 1995–1997 we conducted a white pine blister rust (WPBR) disease survey in white pines of the Intermountain West. Incidence of WPBR in white pines was 59% overall, 73% in the northern Rocky Mountains, 55% in the middle Rocky Mountains, and 67% in the Sierra Nevada sample stands. Intensity within infected stands averaged 35% and ranges from 2% to 100%. Southward spread of the disease along the western slope of the Rocky Mountains appears to have slowed or stopped, and the disease was found at the northern and western edges of, but not within, the Great Basin region. Smaller-diameter trees infected with WPBR sustained more severe damage than larger-diameter trees. Mortality and topkill caused by WPBR were very low across the entire study area, but incidence and intensity of the disease appear to have increased substantially in the northern and middle Rocky Mountains since the 1960s.

Keywords: damage survey, distribution, limber pine, white pine blister rust, whitebark pine
Folder: WPBR distribution Location: file

Smith, J.P.; Hoffman, J.T.; Sullivan, K.F.; Van Arsdel, E.P.; Vogler, D. 2000. First report of white pine blister rust in Nevada. Plant Disease. 84(5):594.

Abstract: White pine blister rust, caused by *Cronartium ribicola* Fisch., was found in 1997 infecting white pines (genus *Pinus*, subgenus *Strobus*) at two locations in the Carson Range of western Nevada...

Annotation: At Mt. Rose on whitebark pine. Near Genoa Park on western white pine. In September 1998 at Mt. Rose, observed aecia at peak, no telia on *R. cereum*, *montigenum* and *nevadense*, most cankers on wood formed 1978-79, oldest 1968, youngest 1980. In October 1998 at Babbitt Peak, observed fresh aeciospores, *R. montigenum* and *cereum* not infected, cankers on wood 1978-80. Rust not found at 10 other sites.

Keywords: distribution, white pine blister rust
Folder: Ribes, WPBR distribution Location: file

Spaulding, P. 1922a. Viability of telia of *Cronartium ribicola* in early winter. Phytopathology.

Annotation: Telia on green leaves (or recently frost-killed) germinated well; telia on dead (dry) leaves did not germinate. *Ribes nigrum* is far the most dangerous species because: (1) The plant is nearly maximum in height. (2) Its is maximum in vigor of growth. (3) It produces new growth throughout the season. (4) It produces new shoots and leaves to a maximum lateness in the season. (5) It produces a maximum area of leaf surface. (6) It is more susceptible than other species. (7) A maximum number of telia per unit of leaf area are produced on this host. (8) These telia are of maximum vigor in germination and production of sporidia. (9) the telia are of maximum longevity in the season. [Useful guide for identifying some of the factors involved in ranking the epidemiological importance of various ribes species.] Telia on ribes will remain alive in the winter and will germinate readily when the temperature rises above freezing, but it remains to be determined whether the pines are in condition to become infected.

Keywords: white pine blister rust, epidemiology
Folder: Ribes, WPBR distribution Location: pathology, Ribes Folder

Thrall, P.H.; Burdon, J.J. 1997. Host–pathogen dynamics in a metapopulation context: the ecological and evolutionary consequences of being spatial. *Journal of Ecology*. 85(6):743–755.

Abstract: The metapopulation concept is useful when considering ecological and evolutionary dynamics of spatially structured populations. Recent theory suggests that the dynamics (epidemic vs. endemic) and migration rates of host and pathogen will be important factors in the maintenance of genetic polymorphisms in resistance and virulence. We argue that the relative spatial scales at which hosts and pathogens interact are crucial to understanding the evolution of resistance/virulence structure. We predict that life-history features that influence encounter rates between specific host and pathogen genotypes will be important factors in determining the evolution of resistance/virulence structures. Understanding the co-evolution of plant-pathogen systems will require research programmes that integrate long-term descriptive and experimental studies of multiple populations, with analytical and computer simulation modeling and comparative/phylogenetic studies.

Keywords: biogeography, epidemiology, life history, population genetics

Folder: WPBR distribution

Location: file

Toko, E.V.; Graham, D.A.; Carlson, C.E.; Ketcham, D.E. 1967. Effects of past *Ribes* eradication on controlling white pine blister rust in northern Idaho. *Phytopathology*. 57:1010.

Abstract: An evaluation was conducted to determine the incidence of white pine blister rust in western white pine stands with a history of *Ribes* eradication. Fifty-three stands ranging in age from 4 to 21 years were surveyed. The proportion of trees infected varied directly with age. Stands were found to have an average infection rate of 3% per year. *Ribes* populations within the stands and in protection zones around the stands were found to have little or no correlation with the annual infection rate. [entire article]

Keywords: western white pine, white pine blister rust, disease control, *Ribes*

Folder: *Ribes*, WPBR distribution

Van Arsdel, E.P.; Sterns, F.W.; Main, W.A. 1968. Temperature in a circular clearing the forest. *Bulletin American Meteorological Society*. 49(3):301.

Annotation: A forest opening was selected for intensive temperature and humidity measurements.

Keywords: climate

Folder: WPBR distribution

Location: file

Van Arsdel, E.P. 1960. Infection decline rates in alternate host eradication rust control. *Phytopathology*. 70(6):572.

Abstract: Determining the distance required in eradication control of rust presupposes its effectiveness. *Ribes* eradication had been determined to be effective before white pine blister rust control work was started (Bulls 2, 4, & 6, Am Pl Pest Cont Com, 4 Joy St. Boston, Mass, 1918–20 and 1924 Jour Ag. Res. 28:1253–1258). My review of 30 yrs of Lake States tests also showed effective control (Abstr. 1st Intern Cong. Pl Path, London, 1968). Distances necessary for *ribes* removal were determined from exponential dilution curves; the number of infections/plant declined in proportion to the square root with distance. In a high hazard area a 12 ft tree to *ribes* would have 36 cankers; a tree 300 ft away 6; a tree 600 ft away, 2.54 cankers; one 900 ft away, 1.57 cankers; and one 1800 ft away, 1.06 cankers. In the northern Lake States infection decline curves were made from incidence data in three areas in which the sq rt distance was 300 ft. In low-hazard Calif, the decline rate sq rt distance was 25 ft (USDA Tech Bull 1251, 1961). Eradication distance should equal twice the sq rt distance along locally made decline curves. [entire article]

Annotation: For more information see unpublished lecture notes by Van Arsdel titled "Using infection decline curves in alternate host eradication rust control" (September 24, 1979).

Folder: WPBR distribution

Location: file

Van Arsdel, E.P. 1961. Growing white pine in the Lake States to avoid blister rust. Stn. Pap. 92. Madison, WI: U.S. Department of Agriculture, Forest Service Lake States Experiment Station.

Annotation: White pine. Blister rust. Factors influencing control. Conditions necessary for spread of rust. Growing white pine to avoid blister rust. Includes both regional- and silvicultural-scale considerations based on climatic effects on rust.

Keywords: eastern white pine, white pine blister rust, disease control
Folder: WPBR distribution Location: pathology

Van Arsdel, E.P. 1962a. Some forest overstory effects on microclimate and related white pine blister rust spread. Tech. Note 627. St. Paul. MN: U.S. Department of Agriculture, Forest Service, Lake States Experiment Station.

Keywords: eastern white pine, white pine blister rust, pest hazard, climate
Folder: WPBR distribution Location: pathology

Van Arsdel, E.P. 1965a. Relationships between night breezes and blister rust spread on Lake States white pines. Res. Note LS-60. St. Paul. MN: U.S. Department of Agriculture, Forest Service, Lake States Forest Experiment Station.

Keywords: eastern white pine, white pine blister rust, climate, epidemiology
Folder: WPBR distribution Location: pathology

Van Arsdel, E.P. 1965b. Micrometeorology and plant disease epidemiology. Phytopathology.

Annotation: This discussion is confined to those microclimatic variations that result in important changes in disease incidence and that can be used to control the disease in certain conditions. Emphasis is on principles rather than details. Topics are: local temperature and/or moisture differences, radiation effects, air drainage, and night breezes applied to several diseases including white pine blister rust in the Lake States.

Keywords: white pine blister rust, epidemiology, pest hazard, climate
Folder: cbr weather, WPBR distribution Location: file

Van Arsdel, E.P. 1967. The nocturnal diffusion and transport of spores. Phytopathology. 57:1221–1229.

Abstract: Information on the time of spore release in the diurnal cycle shows that spores released at night play an important role in the spread of some major plant diseases. Spores released at night encounter different environmental conditions than spores released during the day. Many spores released at night are smaller and lighter and thereby spread better in the nocturnal environment. Traditional statistical diffusion theories do not apply to night-released spores. On the assumption that the spores go where the winds blow, the theory is advanced that spore clouds exist in a structured atmosphere and that these structures are stable and found to a greater extent at night. The relation of traced airflow to the spread of white pine blister rust sporidia illustrates the usefulness of tracer methods, because blister rust infections can be seen on pine and dated for many years after the infection occurs. For example, the locations of the cankers in trees and tracer studies show that lake breezes from Lake Michigan and Lake Superior control the location of blister rust infections on white pines. The spores nearest the lakes are blown over the water at night so pines near the Great Lakes rarely have rust. A higher flow of air toward the land carries the spores 10–17 miles from the lake where downdrafts deposit the spores to make numerous infections high in the trees and far from the nearest Ribes.

Keywords: dispersal gradient, epidemiology, pest hazard, spatial analysis, white pine rust
Folder: cbr weather, WPBR distribution Location: file

Van Arsdel, E.P. 1969. Blister rust epidemics in the evolution of white pines. In: Abstracts. XI International Botanical Congress; 1969 August 24–September 2; Seattle, WA.

Abstract: Meteorologically sustained epidemics of the blister rust fungus on Haploxylon pines could have shaped the evolution of resistance to *Cronartium ribicola* during the Pleistocene. According to this theory, *Pinus armandii* was the first host of the rust among the *Cembra* and the *Strobi*. The susceptibility of a pine species to the rust increased with the distance of its home range to that of *P. armandii*. Rusts were present on the white pines before the breaking of the continuous Eurasian-American white pine range during the Pliocene; therefore, the mutations giving rise to *C. ribicola* occurred in the early Pleistocene. In Eurasia during glacial periods, different species of pine were isolated for 50,000–150,000 yr. periods in mountainous areas with cool wet weather prevailing. During each glaciation the pines in small refuges with rust present were selected for resistance. After each glaciation the pines spread extensively from these refuges. Eg. in the Nebraskan Glaciation only *P. armandii* was isolated with the fungus. In the Aftonian Interglacial the resistant *P. armandii* spread out in mixed forests and *P. griffithii* + *peuce* became infected. *P. griffithii*+*peuce* was selected for the first time during the Kansan. During the Illinoian, susceptible trees of *P. griffithii*, *P. koraiensis*, and *P. parviflora* were selected out. Susceptible *P. cembra* was selected out in the Wisconsin. *P. sibirica* maintained a large discontinuous range in the last two glaciations so susceptible trees survived. All new world species of *Cembra* and *Strobi* are susceptible. [Entire]

Keywords: biogeography, white pine, white pine blister rust
Folder: WPBR distribution

Van Arsdel, E.P.; Krebill, R.G. 1995. Climatic distribution of blister rusts on pinyon and white pines in the USA. In: Kaneko, S.; Katsuya, K.; Kakishima, M.; Ono, Y., eds. Proceedings 4th IUFRO Rust of Pines Working Party Conference; 1994 October 2-7; Tsukuba, Japan. Kukizaki, Japan: Forestry and Forest Products Research Institute, Forest Microbiology Section: 127-133.

Abstract: Surveys of the pinyon pine blister rust were made on pine May 1992, 1993, and 1994, and on *Ribes* in August of 1993. There was a zone without *Ribes* at the lowest (driest level) than a zone with *Ribes* but no rust. Above this zone various percentages of the pines were infected. The percentage of infected trees was found to be highest in a belt from 6300 to 6700 feet elevation on three Great Basin Mountain Ranges. Above 6700 feet there was less rust although there were abundant *Ribes* and numerous pines with good growth. The rust distribution seems to depend on spore transport as well as temperature and moisture distribution. The greatest concentration of infected trees seems to occur at the backflow recharge area of slope drainage winds where spores are carried in night breezes and the areas are cool and wet enough to favor rust infections.

Keywords: climate, pinyon pine, pinyon rust, white pine, white pine blister rust
Folder: *Ribes*, WPBR distribution Location: file, pathology

Van Arsdel, E.P.; Riker, A.J.; Kouba, T.F.; Suomi, V.E.; Bryson, R.A. 1961. The climatic distribution of blister rust on white pine in Wisconsin. Stn. Pap. 87. St. Paul. MN: U.S. Department of Agriculture, Forest Service, Lake States Experiment Station. 34 p.

Annotation: In certain large areas of southern Wisconsin where rust had been present on well-distributed *Ribes* bushes, white pines were, nevertheless, generally free of infection. In southern Wisconsin, cankers occurred less than 5 ft above the ground and were limited to trees in openings and kettle holes. Rust was most frequent in sheltered valleys, at bases of slopes, and small forest openings. These factors are related to temperature (average July temperature) and moisture (high near ground, bottoms, and small openings).

Keywords: eastern white pine, white pine blister rust, epidemiology, pest hazard, climate
Folder: cbr weather, WPBR distribution Location: file, pathology

Van Arsdel, E.P.; Riker, A.J.; Patton, R.F. 1956. The effects of temperature and moisture on the spread of white pine blister rust. *Phytopathology*. 46(6):307–318.

Annotation: To increase our understanding of how temperature and moisture influence the spread of the white pine blister rust fungus, studies were made of the influence of these factors in relation to production and germinability of the spores of *Cronartium ribicola*.

Keywords: white pine, white pine blister rust, epidemiology, weather

Folder: cbr weather, WPBR distribution

Location: file

Wendland, W.M.; Bryson, R.E. 1981. Northern hemisphere air stream regions. *Monthly Weather Review*. 109:255–270.

Abstract: Near-surface air stream source regions of the northern Hemisphere have been identified using 16-year means resultant winds from 3 degree latitude by 3 degree longitude grids. Tracing the airstreams back to their divergent centers reveals 19 different sources during various seasons of the year.

Keywords: climate

Folder: WPBR distribution

Location: file

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