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EVALUATION OF WHITE PINE BLISTER RUST DISEASE ON THE SHOSHONE NATIONAL FOREST

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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.

Introduction

White pine blister rust (*Cronartium ribicola)* is a disease of white pines that is severely impacting many whitebark pine (*Pinus albicaulis)* stands of the Northern Rocky Mountains (Keane and Arno 1993, Keane et al. 1994). In some sites in northern Idaho and Montana, the rust infects 83 - 90% of the whitebark pines (Keane et al. 1994, Kendall and Arno 1990) and has caused 42% mortality within the last 20 years (Kendall et al. 1996). An even greater loss has occurred on these sites as infected trees are topkilled by the rust fungus and then are "functionally killed" due to their inability to produce seed (Keane et al. 1994). The disease may also be causing a noticeable decline in many of the limber pine (*Pinus flexilis)* stands in the Rocky Mountains.

Recognizing the destructive potential of this disease to the Shoshone National Forest's whitebark pine and limber pine stands, Region 2 Forest Health Management - Rapid City Service Center (FHM) conducted a survey for the disease in 1996. Low incidence levels of the disease were found during the survey. However, two areas of moderate to high infection levels were found on the Shoshone National Forest and FHM started long term monitoring of the disease on these sites by establishing permanent plots.

Thirteen permanent plots were installed in 1997 and 1998 to study the spread of white pine blister rust for at least 20 years. Ten of these plots are located on the Shoshone National Forest and three plots are in Yellowstone National Park. Plots were installed in the Park on the eastern side of the Continental Divide because the area is part of the Absaroka Mountain Range in the Shoshone National Forest. This area may be a corridor for the continued spread of the disease to the Shoshone National Forest. This report describes the locations of the survey sites and permanent plots and the various infection levels that were found at each site. This information will represent baseline data for comparisons at later dates.

History and Ecology of White Pine Blister Rust on the Shoshone National Forest

White pine blister rust disease was introduced to western America in the early 1900's when infected white pine seedlings from Europe were planted in British Columbia. The disease was first seen infecting whitebark pine in 1922 in Canada and in 1943 the rust was reported to be causing severe mortality (Hoff et al. 1992). The white pine blister rust started to spread throughout the range of all the various white pines in the West and was found in Yellowstone National Park in 1945 (Brown and Graham 1969). Several sites of whitebark pine and limber pine in Wyoming forests were surveyed in the 1960's and the disease incidence at that time was described as low with only 6% of the surveyed trees infected with the disease (Brown and Graham 1969, Brown 1978).

While the disease has been present in Wyoming for almost 50 years, recent surveys in the Targhee and Bridger-Teton National Forests in Wyoming, west of the Continental Divide, indicate the incidence and severity of the rust disease infections has increased. The smaller whitebark pine trees are suffering more damage; topkill and mortality are increasing in the mature trees (Smith and Hoffman 1998). Other recent survey work in Yellowstone and Grand Teton National Parks indicates the disease incidence is increasing and spreading into new areas (Kendall et al. 1996).

Currently, white pine blister rust is most often found at low to moderate levels of infection in whitebark pine and limber pine stands of Wyoming forests east of the Continental Divide (Brown 1978). This is partly due to the rain shadow effect on the eastern slopes and the drier conditions. However, the rust fungus has proven to have a great ability to genetically adapt to various climates, perhaps because of its five spore stages in its life cycle (G. McDonald, Pers. Com.). Two of these spore stages (pycnia and aecia) grow on whitebark and limber pines in Wyoming. The other three spore types (uredia, telia, and basidia) are produced on the alternate hosts, currant and gooseberry plants (*Ribes* spp.) (Boyce 1948).

C. ribicola is a fungal pathogen that infects white pine trees when its basidia are blown from *Ribes* plants and penetrate pine needles. Fungal hyphae grow into pine shoots, and then develop into branch cankers that girdle and kill the branch. If the branch cankers are within close proximity to the main stem of the tree, then the canker may be able to grow into the stem and girdle the stem. The upper portion of the stem above the girdling canker dies and the canker then continues to advance down the stem, killing more or the tree's crown (Boyce 1948). The rust disease prevents the tree from producing seed since the tree can not produce cones in the topkilled stem (Keane et al. 1994). This disease may also predispose the white pines to other pathogens or damaging insects (Krebill and Hoff 1995).

Importance of Whitebark and Limber Pines on the Shoshone National Forest

Whitebark pine has been described as a "keystone" species that affects many plant and animal communities. This species grows slowly and starts producing cones at about 100 years of age. It grows under dry, windy, and heavy snowload conditions in areas where no other vegetation can grow. Whitebark pine is a major component of alpine communities and can alter the microclimate of a harsh site which then allows other plants to become established. This tree is also a major component of seral, mixed conifer stands in the Rockies. It is shade intolerant and is usually propagated from Clark's nutcracker seed caches in recently disturbed sites (Kendall and Hoff 1995).

Whitebark pine seed is high in fat and protein and is cached by several animals such as the threatened and endangered grizzlies. Grizzly bears, especially gestating sows, raid squirrel caches in the fall and use the whitebark pine seed as a main food source prior to hibernation (Kendall and Hoff 1995). Kendall and Arno (1990) found that during years of poor whitebark cone crops, bear-human conflicts increased which resulted in increased bear mortality. This was due to the bears searching for alternative food sources at lower elevations. With the decline in whitebark pine stands over the last 50 years, due in part to the rust disease, there has been a noticeable reduction of whitebark pine seed in bear scat (Kendall and Arno, 1990).

Limber pine has little timber market value in Wyoming, but is an important tree for vegetation purposes. Limber pine grows on harsh sites where very little other vegetation can grow. This tree species may help alter the site to allow other vegetation to become established. White pine blister rust disease on limber pine may then become more of a concern to forest managers as they try to promote this tree species. Limber pine may also maintain rust incidence on a site, promote increases in population levels as the rust continues its lifecycle, and then spreads into nearby stands with whitebark pine.

Methods

Survey and permanent plot sites were chosen throughout the Shoshone National Forest (Figure 1). Due to limited time and resources for the project, the sites needed to be accessible by a vehicle and/or a two-mile hike. Sites were selected that had a large component of whitebark or limber pine in the stands. Three of the permanent plots were located on or near wildlife management's transects that are used for monitoring whitebark pine cone/seed production for wildlife. Sites were named for nearby landmarks and the general locations and host tree species of these sites are listed in Table 1.

Figure 1. Map of the survey sites and permanent plots to study white pine blister rust disease on the Shoshone National Forest (NF) and in Yellowstone National Park (NP). Each location on the national forest was surveyed in 1996. Seven sites were selected for installation of permanent plots for long term disease monitoring in 1997 and 1998.

Table 1. General locations of the survey sites (ss) and the permanent plots (pp) in the Shoshone National Forest and Yellowstone National Park (YNP). Sites were named for nearby landmarks of the area. The host pine species and mixed conifer or pure stand compositions are listed.

Survey sites and number of permanent plots	General locations by Townships, Ranges, and Sections	Host pine species and stand composition
Republic Mtn. 2 pp	T.58N. R.108W. S.20	Whitebark - mixed
Beartooth Hwy ss	T.57N. R.106W. S.17, 12	Whitebark - pure
Chain Lakes ss	T.57N. R105W. S.24, R.104W. S.19	Whitebark - pure
Sunlight Bridge ss	T.55N. R.104W. S.6	Limber - mixed
Dead Indian Pass 2 pp	T.55N. R.104W. S.15, R.103W. S.25	Limber - pure
Eleanor Lake, YNP 3 pp	T.52N. R.110W. S.18	Whitebark - mixed
Pahaska Teepee ss	T.52N. R.109W. S.3	Whitebark - mixed
Togwotee Pass 2 pp	T.44N. R.110W. S.28	Whitebark - mixed
Horse Creek, 1 pp	T.43N. R.107W. S.10	Whitebark - mixed
Pilot Knob, 1 pp	T.43N. R.110W. S.3	Whitebark - mixed
Tie Hack Memorial ss	T.43N. R.109W. S.34	Limber - pure
Louis Lake Lander 2 pp	T.31N. R.101W. S.36	Whitebark - pure

The methods for the survey and the permanent plot installation were different. However, tree and disease data in both the survey and permanent plots installation were collected using similar methods.

Survey

Chain-wide transects were traversed for at most 10 chains or 100 host trees at each survey site. Only limber pine and whitebark pine with stems larger than 4" dbh were evaluated and many were found growing in shrublike groups. Each stem was recorded as a separate tree and noted that it was growing in a group with other stems.

Tree data were collected for species, dbh, crown class, crown ratio, and tree heights. Health status of the tree was evaluated as:

- "healthy" for no signs/symptoms of damage,
- "declining" for one to three incidences of damage,
- "dying" for four or more damages, and
- "dead due to the rust" or "dead due to other factors".

Other damaging agents of the tree were noted and increment cores were taken on every tenth tree to determine age.

Rust damages were assessed by evaluating visible cankers. Canker heights and percent girdling were recorded for each stem canker. Branch heights of branches with girdling cankers within three feet of the stem were noted. The number of branch cankers beyond three feet of the stem were totaled for each tree.

Permanent Plots

The permanent plots were fixed radius, circular plots that measure 1/10 acre in size; two of the plots were only 1/20 acre in size due to site constraints. Reference point trees were marked near the road and along hiking trails according to local forest managers' instructions. The plot centers were marked with an orange, hooked, rebar metal stake. All plot trees had a dbh of at least 4 inches. These trees were tagged with a numbered, metal tag at dbh level facing towards plot center. Mensurational data, health status, and rust damages as described above in the survey were recorded for each tree. Other damaging agents of the trees were recorded; ages were taken from three plot trees of each species for ages and site index calculations.

Regeneration was recorded for each plot with the use of three, 1/300 acre, circular subplots. Seedlings (trees less than 4.5 feet tall) were evaluated for species, height, and rust damages. Saplings (trees with a dbh between 0.1 - 3.9 inches) were recorded by species, dbh, height, and rust damages. Saplings were wired with a numbered, metal tag that will become their tree number as they increase in diameter and "grow into" the plot.

Samples of understory vegetation and *Ribes* plants were collected from the plots and identified to genus and species. The understory vegetation will be used to determine habitat types. The species, percent ground cover, and average heights of the *Ribes* were recorded for each species on the plot. Unfortunately, the permanent plots have not been revisited during the season when rust infection of the *Ribes* plants could be observed. Hopefully, future work on the plots by FHM will provide information about the rust infection of *Ribes* in the area.

Data from all the host trees of both the survey and permanent plot sites were analyzed. Each host tree was categorized for rust severity according to it's most serious rust sign/symptom. The rust severity categories were:

- no rust disease,
- multiple branch cankers,
- non-girdling stem cankers,
- girdling stem cankers, and
- mortality due to the rust.

To determine rust disease level, counts of the rust severity categories were made for each site. The percent infections of each site were calculated and then classified into four disease levels:

- 0 = no rust disease,
- 1 = less than 10% of host trees infected,
- 2 = less than 50% of the host trees infected, and
- 3 = 50% or more of the host trees infected.

Results

The percent infection and rust disease levels at each site are presented in Table 2. Low to moderate 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. Republic Mountain with mixed conifer, whitebark pine stands and Dead Indian Pass with pure, limber pine stands had disease incidences over 50%. The Sunlight Bridge, Eleanor Lake NP, Togwotee Pass, and the Louis Lake areas contained moderate levels of the disease with incidences ranging from 12% to 15%. The Horse Creek area near Dubois had a low incidence of rust, while five sites had no visible signs of the rust disease.

Trees with girdling stem cankers were found on three sites: Republic Mountain, Dead Indian Pass, and Louis Lake. Only Republic Mountain had one mature tree mortality that could be confirmed to be caused by the rust. While disease incidence was high at Dead Indian Pass, there were several other damaging agents on the site. Dwarf mistletoe *(Arceuthobium cyanocarpum)* and mountain pine beetle *(Dendroctonus ponderosae)* exist on this site. Also a possible needlecast disease may be present on the site. It was difficult to ascertain which

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damaging agents were responsible for the mortality on the site. However, white pine blister rust incidence was high on the site and a critical factor in the decline of the limber pine.

Ribes lacustre, R. laxiflorum, and *R. viscosissimum* were identified on the permanent plots. The percent ground cover of the *Ribes* are listed in Table 2. Sites with more than one permanent plot have an average percent ground cover reported. It is interesting to note that the two sites with high disease incidence
on the pines, also had more *Ribes* plants on the plot.

Table 2. Percent infected whitebark pine and limber pine trees of each survey and permanent plot site on the Shoshone National Forest and one site in Yellowstone National Park (YNP). The white pine blister rust (WPBR) levels of infection are classified as: 0 = no rust disease observed, 1 = less than 10% of host trees infected, 2 = less than 50% of host trees infected, and 3 = greater than 50% of host trees infected. The percent ground covers by *Ribes* plants for each site are listed.

Site Name	% Infection	WPBR level	*Ribes* spp. % ground cover
Republic Mountain	60	3	5
Beartooth Highway	0	0	0
Chain Lakes	0	0	0
Sunlight Bridge	15	2	1
Dead Indian Pass	52	3	10
Eleanor Lake, Y.N.P.	12	2	1
Pahaska Teepee	0	0	0
Togwotee Pass	13	2	0
Horse Creek	5	1	1
Pilot Knob	0	0	0
Tie Hack Memorial	0	0	0
Louis Lake	15	2	0

Discussion

The two sites with high levels of rust were interesting for comparisons with the other survey and permanent plot sites. Republic Mountain contained two plots; one plot was in mature whitebark. The second plot was in an avalanche area that had occurred recently and consisted of heavily infected whitebark pine seedlings and saplings. It is likely that this disturbed, open area attracted Clark's nutcrackers to cache seeds on the site. Studies have shown that this bird is most likely to cache its whitebark pine seeds in disturbed sites (Kendall and Arno 1990, Lanner 1993).

There were several damaging agents causing the mortality at the Dead Indian Pass sites. Dwarf mistletoe, mountain pine beetle, *Ips* spp. beetle, and white pine blister rust were all found. An unidentified foliage disease may also be contributing to tree mortality in this area as well. Limber pine stands in Montana exhibiting a similar type of decline were recently diagnosed as having a severe infection of *Dothistroma septospora* needle blight disease (Taylor and Schwandt, 1998). FHM will conduct additional studies into the possibility of the needle blight disease and the other multipest problems of this area. Shoshone National Forest managers are removing the dead trees to reduce the fuel load of the site. Perhaps this will also help reduce the various pest activities on the site.

Interesting comparisons of Republic Mountain and Dead Indian Pass sites with the few other low infection sites in the survey and permanent plots work were the differences in the amounts of *Ribes* plants. Both Republic Mountain and Dead Indian Pass areas contained large amounts of *Ribes*. Although the alternate host does not need to be close to white pines to spread the rust spores that infect the pines, perhaps having both hosts, pine and *Ribes*, on a site allows the rust to remain on the site and complete its lifecycle. This may lead to increased rust population levels on the site. Perhaps the disturbances on these two sites, the avalanche at Republic Mountain and multipest activities at Dead Indian Pass, provided good sites for *Ribes* and allowed this alternate host to become more prolific.

The four sites with moderate levels of infection will be monitored to see if these sites will show an increase in white pine blister rust disease. These sites have very little *Ribes* vegetation, which may be a reason for the lower incidences of white pine blister rust on the sites.

Another possible explanation of the lower incidence of the disease on the Shoshone National Forest may be a climate effect on the *Ribes* plants. FHM found the aecial spores, blisters on the pines, late in July and August, so the spread of these spores to the *Ribes* occurs later in the summer and into the fall. Perhaps winter arrives too soon after the spore dispersion from the pine to the *Ribes*. The rust fungus may not have enough time to mature on the *Ribes* and then spread to nearby trees before leaf drop in the fall for the *Ribes*. However, the northern Rocky Mountains may have similar seasonal conditions and yet the disease has survived on both the pine and *Ribes* hosts. White pine blister rust has been successful in severely damaging several whitebark pine stands in these areas (Keane and Arno 1990, Keane et al. 1994). If the right climatic conditions exist on the Shoshone National Forest, then it is possible for increased rust spore spread to new areas of the forest.

There are many other sites on the Shoshone National Forest with whitebark pine that were inaccessible during this survey and permanent plot work. It would help with future surveys and searches for resistant whitebark pine if forest managers and field crews would be trained to identify and look for the disease. As they work in areas with whitebark pines, they could quickly evaluate the trees and report their observations to the forest to help provide more information about white pine blister rust disease in the whitebark pine stands on the Forest.

The Shoshone National Forest has an unique opportunity with the relatively low levels of white pine blister rust disease to protect valuable whitebark pines. Investigations should be initiated into promoting whitebark pine habitat and locating resistant whitebark pine trees for seed collection. Low intensity prescribed fires may be a good management tool to create suitable sites to encourage nutcrackers' seed caches (Tomback et al. 1995). Prescribed fires would also remove competing climax vegetation such as subalpine fir (*Abies lasiocarpa)*. Resistant trees are believed to exist throughout the range of whitebark pine (Kendall and Hoff 1995) and local resistant trees need to be identified and protected to provide a valuable seed source for future plantings. Perhaps with timely investigation work into whitebark pine resistance, the Shoshone National Forest will be able to maintain a viable population of whitebark pine for wildlife, biodiversity, and timber purposes in the future.

Recommendations

Find resistant trees to white pine blister rust disease and promote their seed collection.

Promote whitebark pine habitat with subalpine fir reduction. This will provide the whitebark pines with the less competition and a better opportunity to resist/tolerate the rust disease. Train field personnel to identify and look for the rust disease whenever they are in whitebark pine stands, especially in wilderness and roadless area. Develop reporting methods for disease incidence and intensity. FHM should continue to monitor the permanent plots and assist with suppression efforts to promote whitebark pine habitat and search of resistant trees.

References

Boyce, J.S. 1948. Stem disease: rusts of conifers. Forest Pathology, 2nd ed. McGraw-Hill Book Company, Inc. New York, Toronto, London: 206-209.

Brown, D.H. and Graham, D.A. 1969. White pine blister rust survey in Wyoming, Idaho, and Utah: 1967. USDA Forest Service, Northern Region, State and Private Forestry Report. 11 pp.

Brown, D.H. 1978. The status of white pine blister rust on limber pine and whitebark pine in Wyoming. USDA Forest Service, Rocky Mountain Region, Tech. Report: R2-13.

Hoff, R.J.; Hagle, S.K.; and Krebill, R.G. 1992. Genetic consequences and research challenges of blister rust in whitebark pine forests. Proc. of International Workshop on Subalpine stone pines and their environment; St. Moritz, Switzerland, Sept. 5-11, 1992; p.118-126.

Keane, R.E. and Arno, S.F. 1993. Rapid decline of whitebark pine in Western Montana: evidence from 20-year remeasurements. Western Jo. Applied Forestry 8 (2): 44-47.

Keane, R.E.; Morgan, P.; and Menakis, J.P. 1994. Landscape assessment of the decline of whitebark pine (*Pinus albicaulis)* in the Bob Marshall Wilderness Complex. Montana, USA. Northwest Science 68 (3) 213-229.

Kendall, K.C. and Arno, S.F. 1990. Whitebark pine - an important but endangered wildlife resource. Pages 264-273 in Schmidt, W.D. and McDonald, K.J. compilers. Proceedings of a symposium on whitebark pine ecosystems: Ecology and management for a high mountain resource. USDA Forest service, Intermountain Research Station, Gen. Tech. Rep. INT-270.

Kendall, K.C. and Hoff, R.J. 1995. An introduction to whitebark pine ecology and status. Proc. of the 43rd annual Western International Forest Disease Work Conference; comp. Mathiasen, R.L.; Whitefish, MT; Aug.29 - Sept.1, 1995. p.97-102.

Kendall K.; Schirokauer, D.; Shanahan, E.; Watt, R.; Reinhart, D.; Cain, S.; and Green, G. 1996. Whitebark pine health in Northern Rockies National Park Ecosystems: a preliminary report. Nutcracker Notes; USDA Forest Service Intermountain Research Station; Missoula, MT; Dec. 22, 1996; Number 7: 16-23.

Krebill, R.G. and Hoff, R.J. 1995. Update on *Cronartium ribicola* in *Pinus albicaulis* in the Rocky Mountains, USA. Proc. 4th IUFRO Rusts of Pines, Working Party Conf., Tsukuba: 119-126.

Lanner, R.M. 1993. Is it doomsday for whitebark pine? Western Journal of Applied Forestry 8:47,70.

Smith, J. and Hoffman, J. 1998. Status of white pine blister rust in Intermountain Region white pines. USDA Forest Service, Intermountain Region, Report No. R4-98-02.

Taylor, J.E. and Schwandt, J.W. 1998. Dothistroma needle blight on limber pine in Montana. USDA Forest Service, Northern Region, Rep. 98-4.

Tomback, D.F.; Clary, J.K.; Koehler, J.; Hoff, R.J.; and Arno, S.F. 1995. The effects of blister rust on post-fire regeneration of whitebark pine: the Sundance Burn of Northern Idaho (U.S.A.). Conservation Biology 9 (3): 654-664.

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