Blister Rust Survey and Monitoring Data Sheet
Belt Transect Plot Description and Understory Survey

Plot No: ________ Start Monument Tag #: _ _ _ End Monument Tag #: _ _ _

Date (mm/dd/yyyy): _ _ _ _ _ _ _ _ Field Team: ______________________________

State/Province (2-letter code): _ _ Administrative Unit: ______________________________

Specific location: ____

Units of measurement (check): Metric ( ) English ( ) Topo Map ID: ______________

Type: Transect ( ) Circle ( ) Rectangle ( ) Length (nearest 1.0 m or 1.0 ft): ________

Center of plot: Elev: _____ m ft (circle one) Slope: ___ % deg (circle one) Aspect (to 10°): _____

Start GPS: NAD: _ _ Zone: _ _ Easting/Long: ________ Northing/Lat: __________ Accuracy: __

End GPS: NAD: _ _ Zone: _ _ Easting/Long: ________ Northing/Lat: __________ Accuracy: __

Compass direction of transect (True North): at Start: _______ at Center: ________

Successional status (C, L, M, E): _____

Habitat type: ___________________________ Cover type: ______________________

Reference for above: ____

Estimated percent of each tree species in overstory: ______________________________

____

Undergrowth dominants: ____

____

Photo info. (roll/number): Along transect from origin: ______ End of right belt: ______

Along transect toward origin: _______ End of left belt: _______ Other: ______________

Rust resistant candidate trees (plus trees), tag # and GPS location: __________________

____

Comments (cone production, nutcracker activity, etc.): ______________________

____

____

____

____

UNDERSTORY SURVEY: trees < DBH (1.4 m)

Complete this tick mark matrix for all LIVE understory whitebark pine within the belt transect.

Height < DBH	Active Cankers	Inactive Cankers	No Cankers
≤ 50 cm (20 in)			
> 50 cm (20 in)			

Plot No.: Date:

Tree No.	Tag # or Dist Along/From Tape	Clump letter a,b,...	DBH	Tree status H,S,R,D	Stem Cankers A,I,N,U,O	Branch Cankers A,I,N,U,O	Canopy Kill % class	Bark Strip N,L,H	MPB Pres. √	Cause of Death R,B,U	Notes
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Cankers: A=active (spores), I=inactive, N=none, U=uncertain, O=other; Tree status: H=healthy, S=sick, R=recently dead, D=dead

Canopy kill classes: 1(0-5), 2(6-15), 3(16-25), 4(26-35), 5(36-45), 6(46-55), 7(56-65), 8(66-75), 9(76-85), 10(86-95), 11(96-100)

Bark stripping: N=none, L=light, H=moderate to heavy; Cause of tree death: R=rust, B=beetle, U=unknown/other

August 2, 2004 Lauren Finns - Whitebark Pine

- white pine group mostly 5 needles
- Blister rust introduced to BC (vancouver 1910) + New York
  shipped seeds to Europe, they shipped back seedlings
- originated in Asia, then to Europe, then US
- Reached Idaho 1923
  Primarily noticed in Western white pine
- Timber companies worried
- Blister rust has 5 spore stages w/ two host
  1 = Ribes : Gooseberries + Currants   2 - pine
  infects lvs., they just drop   must go tree -> ribes -> tree, not tree -> tree
- Tried Ribes elimination - effective in east, couldn't do it in the west
- Developed breeding program for WWP
  Sugar pine, Limber pine, Bristlecone pine, etc. all susceptible
- Whitebarks important for squirrel, Clark's nutcracker, Grizzly habitat (high fat + protein) over 50% fat
- WBP one of 5 stone pines - depend on birds for seed dispersal
- Cones don't open or just barely open
  birds work cones while on tree
- store seeds in bolus, travels + hides them
- Whitebark pine foundation -> survey using same techniques to assess habitat
- Genetic study - looking for resistance
- Blister rust enters through stoma of needle
- Lives in phloem, canker grows + encircles tree / branch
  girdles branch or tree, cuts off nutrients

- Canker "fruits", produces spores 2-3 years after infestations, spreads to ribes
- Branch may have fatter areas where cankers are swelling

- also looking for mountain pine beetles
- make galleries - pattern → 
- generally very pitchy

- want to test / breed for resistance
- possibly save in case populations wiped out

WPEF
Summary Field Sheet for
Surveying and Monitoring Whitebark Pine for Blister Rust Infection and Damage

Field equipment:

- **GPS unit (UTM function, NAD83 preferred)**
- **topographic maps**
- **binoculars for each team member (8-10 power, with good light-gathering capability)**
- **wind-up transect tape of 50 m (150 ft) minimum length**
- **5 m (15 ft) metal tape**
- monument stakes (1/2 inch rebar, at least 1.5 ft or 50 cm long)
- small hammer
- **DBH tape**
- **clinometer**
- compass, adjusted for true north
- 100 surveyor's wire stem flags and/or rolls of surveyor's tape
- **clipboard with plot sheet storage**
- waterproof plot data sheets
- fine point permanent markers and graphite pencils
- **numbered aluminum tree tags, tag wire, and aluminum nails**
- **camera**

1. Navigate to GPS point (or otherwise locate plot). Reconnoiter area to determine suitability.

2. **Determine transect direction at beginning of plot. Follow contour as you lay out the plot – so direction may change somewhat. Stay on a compass bearing as much as possible. Do not go up or down in elevation by > 30m (100 ft).**

3. **Monument starting point, attach aluminum tag and take GPS reading and photos (at both ends of the transect looking along the transect and also looking back to the monument from the downhill side).**

4. **Lay out plot as follows: 50 m (150 ft) transect length, 10 m (30 ft) plot width, with 5 m on each side.**
   - **Mark transect plot width with sufficient flagging on trees or flags in the ground to be easily seen.**

5. **Complete blister rust survey and data sheet**
   - **Enter all applicable fields on data sheet.**
   - Complete data sheet for all WBP > 1.4 m. Each tree should be tagged (or distance along/from tape if not tagging). If trees are in clumps (common point of origin) assign consecutive letters to tag # (e.g., tree #1 is a single tree so it would

labeled #2a, 3b, 4c, 5d; the next tree is not a clump so it would just be # 6). If tree obviously splits below DBH, but above the root/base, it is a branch of the tree.

- Record cankers as on the stem or branch, and only one of the following codes in this order of importance (e.g., if both active and inactive cankers, record only the active canker): **A**ctive, **I**nactive, **N**one, **O**ther (cankers, but not from WPBR), or **U**ncertain (unable to see well enough; e.g., lichen cover). An active canker has aecia (spores) present. These can be orange or white eruptions through the bark. Inactive cankers will not have aecia present, but the bark has been ruptured.
- Tree status: (H) Healthy, (S) Sick, (R) Recently Dead, and (D) Dead Snag. Healthy trees have no apparent cankers, pine beetle infestation, canopy kill, or bark stripping. If a tree has cankers, canopy kill, heavy bark stripping, or pine beetle infestation, it should be categorized as "sick." Recently Dead trees still have brown foliage present, and snags are older dead trees with no foliage remaining. A tree is considered living if it has even one branch with green foliage.
- Canopy kill (topkill): The percentage of the total canopy that has been killed (dead branches) is estimated as follows and trees assigned to a category: 1 (0-5%), 2 (6-15%), 3 (16-25%), 4 (26-35%), 5 (36-45%), 6 (46-55%), 7 (56-65%), 8 (66-75%), 9 (76-85%), 10 (86-95%), 11 (96-100%). The entire canopy is considered in the process of making this estimate.
- Presence of bark stripping: (N) None, (L) Light, and (H) Moderate to Heavy. L is defined as a single branch with some degree of stripping. H refers to more than one branch showing bark stripping to any extent, or the stem of a small tree partly or completely stripped.
- Presence/absence of mountain pine beetle: Either beetle entry holes with pitch plugs or j-shaped galleries in the wood indicate presence in a tree (place check mark in column). Removal of a section of stem bark will be necessary to view beetle galleries
- Classify the successional status of this sample stand using the following codes:
  C – Climax or near climax. Site is occupied by tree species that will not change over time in the absence of disturbance.
  L - Late seral. Stand is composed of an overstory of seral and climax species with an understory of climax species.
  M – Mid-seral. Stand is composed of mostly seral species in the overstory.
  E – Early-seral. Stand is composed of shade-intolerant shrubs, herbs, or tree seedlings and saplings.
- Estimate relative proportion of each live tree species in overstory (canopy level or > 5 m), including WBP.
- Name 3 to 5 of the dominant (most commonly occurring) plants in the understory, both woody and herbaceous.
- Key the habitat and cover types from classification most appropriate for your area.
- Complete plot and record plot length to the nearest whole meter.
- Complete understory survey for all live WBP trees in the total plot that are ≤ 1.4 m, using tick/dot matrix at bottom of survey sheet. In the understory survey, clumped seedlings only count as one regeneration "site". Do this survey after you have completed your tree survey.
- Record bearing, aspect and slope steepness (to nearest % or 5 deg.) at center of transect.

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Research Note
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How To Recognize Blister Rust Infection on Whitebark Pine

Ray J. Hoff

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: disease resistance, *Cronartium ribicola*, *Pinus albicaulis*, plant diseases, fungal diseases

White pine blister rust is a disease of five-needle pines. The fungus (*Cronartium ribicola*) infects trees through the needles. It grows down the interior of the needle and into the stem, producing fusiform cankers. Susceptible white pines that are exposed to the disease become infected with one or more cankers. Most die, with just a few remaining canker-free.

The disease is native to Eurasia. It was introduced into western North America in 1910 near Vancouver, BC. Foresters did not notice it until the autumn of 1921. Within 25 years the disease had expanded over most of the range of western white pine (*Pinus monticola*), whitebark pine (*P. albicaulis*), limber pine (*P. flexilis*) and sugar pine (*P. lambertiana*).

The fungus needs two hosts. It is perennial in the inner bark of white pines, and annual on the leaves of currant and gooseberry bushes (*Ribes* spp.). The fungus moves from currants and gooseberries to pine by a very small spore, too small to be visible without a microscope. These spores usually move during the fall, or anytime during extended cool, moist conditions. The fungus moves from the pine to currants and gooseberries in the spring by another type of spore that is small, but can be seen with a hand lens.

The first blister rust canker recorded on whitebark pine was in 1922 at the University of British Columbia arboretum. Infection of natural stands was soon observed. Foresters quickly realized that whitebark pine was several times more susceptible to blister rust than western white pine. Nonetheless, a few whitebark pine trees do not become infected.

The following photos and descriptions of blister rust on whitebark pine (figs. 1 through 19) are to help identify the disease. Forest workers armed with this knowledge can find canker-free trees to start developing a new variety of whitebark pine that is resistant to blister rust. At times some resistance reactions can even be observed (figs. 18 and 19).

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Figures 1 and 2—These red-brown branches (flags) are evidence that blister rust is present.

Figures 3 and 4—The first signs of a stem infection are these yellow-orange patches on the stem. These infections are about 1 year old.

5

6

7

Figure 5—(Above left) This canker is 4 to 5 years old. A yellow-orange margin is visible at the base. The center is rough and broken due to fruiting of the fungus in previous years. The white areas in the lower right side are remnants of fruiting in the current year.

Figure 6—(Above) The fungus within this canker has not fruited, so the bark is still smooth. However, there is a hint of yellow-orange color, especially in the upper one-half of the canker. If this portion were rubbed with a little water, the color would become visible.

Figure 7—(Left) High amounts of sugars are associated with blister rust cankers. Ants, grasshoppers, mice, and other rodents feed on these sweet cankers.


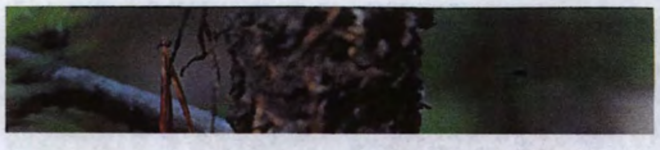

Figure 8—The white material on this canker is the remnant of fruiting during the current year. The fruiting structures originate within the stem. As they grow, the bark ruptures.

Figure 9—This is the lower part of the canker in figure 8. The area has been rubbed with a little water to reveal the yellow-orange margin—a sure sign of a blister rust infection.

Figure 10—Two cankers are visible here. The upper one is still living. The lower one has caused the branch to die. As the fruiting structures of the fungus grow, living cells within the stem are broken, crushed, or dried.

Figure 11—This canker has killed the branch, which has become a "flag". A rodent appears to have made a meal of the sweet, succulent tissue.

12

13

14

Figure 12—(Above left) Fruiting lags a year or two behind the growing margin of the canker. The stem, or top of a tree, does not die until the fungus has grown and fruited completely around it.

Figure 13—(Above) This photo shows the canker that killed the top of the tree in figure 12. Typically, the dead bark is still present and a lot of pitch is associated with the dead portion of the canker. Pitch usually drips and runs down the stem.

Figure 14—(Left) The top of this young tree has been killed by blister rust. A large stem canker is still visible. Several flagged branches and a couple of branch cankers are visible on the middle-right side of the tree.

Figure 15—A fairly old canker. This canker has fruited. However, it doesn't seem to be very active. No yellow-orange margin is visible.

Figure 16—An old, dead canker.

Figure 17—Four dead cankers are visible. Can you find them?

18

19

Figures 18 and 19—Cankers appear to have been suppressed by a defense reaction in the tree. These two trees are resistant to blister rust. Living stem tissue in the area shown is dead. This reaction is similar to that observed in western white pine. The death of host cells may be related to the amount of fungus mycelium present, or to the physical environment. The tree builds a wound periderm around the infection. The death of the pine cells and development of the periderm starve the fungus.

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FACT SHEET

How to recognize

White pine blister rust cankers

Blister rust cankers on stems and branches of white pine are caused by the fungus *Cronartium ribicola* J.C. Fisch. The fungus was introduced to Vancouver on infected imported nursery stock in 1910, and from there it spread throughout the Pacific Northwest over the next 25 years where it continues to decrease stocks of native white pines. Many trees die from one or many blister rust cankers; only a few white pines remain canker free.

The ability to recognize blister rust cankers is a prerequisite to finding canker-free trees. In British Columbia, canker-free trees will be evaluated to determine if they are susceptible trees that have somehow escaped infection or whether they are genetically resistant. Resistant trees, particularly western white pine (*Pinus monticola* D. Don), will be used in tree improvement programs. The purpose of this sheet is to facilitate recognition of blister rust cankers on western white pine so that candidate resistant trees can be chosen more assuredly.

The life cycle of the fungus involves two different hosts; two spore stages are produced on white pine, and three are produced on the alternate hosts, currants and gooseberries (*Ribes* spp.).

Cankers on pine are observed best in the spring, when they produce the characteristic orange aeciospores in aecial blisters (Fig. 1). Branch cankers may be recognized at any time by the orange discoloration in the bark surrounding the swollen, elongated canker (Fig. 2). Initially, in stems with smooth bark, the orange discoloration is highlighted as a diamond-shaped pattern around the point of canker initiation (Fig. 3).

Before aecial blisters form, cankers are difficult to discern. Initially they are small, circular, orange-colored patches, frequently with a fascicle of dead needles in the center (Fig. 4). Small dark areas, pycnia (Fig. 5), develop and exude the first spores, pycniospores, in nectar-like droplets (Fig. 6) during the summer. Pycnia develop annually in the orange margins of cankers; however, the pycniospore droplets often are consumed by insects so they are often difficult to see on the canker.

Older branch cankers are swollen and dark, with roughened bark between orange ends (Fig. 7). This roughened bark is produced by ruptured aecial blisters from former years. Aecial scars are invaded by various opportunistic organisms; boring dust of insects or small, black, orange or red fruiting bodies of invading fungi are often present. These organisms can cause branch dieback to the canker or to the stem. On stem cankers, they cause dead patches and increase resin flow, perhaps causing tree death. On dead branches, the swollen area with roughened bark is the only clue of past blister rust infection (Fig. 8).

Older stem cankers often do not produce pycnia or aecia and the orange margins may be difficult to discern, but they frequently produce resin flow (Fig. 9). Sometimes the canker may distort the stem (Fig. 10). Squirrels often feed on blister rust cankers; this results in bark stripping, resin flow and girdling (Fig. 11). Symptoms similar to those of blister rust, such as distorted stems and resin flow, may also be produced by other agents, such as porcupines or sunscald; trees with such symptoms should be rejected as resistant candidates.

Branch cankers of blister rust may be confused with cankers caused by *Atropellis pinicola* Zeller and Goodd. Black fruiting bodies or their black, circular bases are always present on live branches (Fig. 12). On dead branches, *Atropellis* cankers are typically swollen, as are blister rust cankers, but *Atropellis* cankers are usually flattened on one side (Fig. 13) and lack the roughened bark characteristically produced by aecial ruptures of blister rust (Fig. 7 and 8). *Atropellis* cankers stain the bark and wood black (Fig. 14), whereas blister rust does not invade wood. *Atropellis* cankers are rare on white pine stems and, if present, are about the size of a quarter.

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Canada- British Columbia Partnership Agreement on Forest Resource Development: FRDA II

Canada

BC

White pine cankers

Fig 1-11 *Cronartium ribicola*

Fig 12-14 *Atropellis pinicola*

Field Photos of White Pine Blister Rust on Whitebark Pine

Active canker.

Active canker with sap.

Red "flagging" on a branch is a good place to start looking for BR. Active canker below, rodent chewing and inactive canker.

Inactive canker.

Classic spindle shape of an inactive BR canker.

Active cankers with empty spore sacs.