Methods for Surveying and Monitoring Whitebark Pine for Blister Rust Infection and Damage.

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Whitebark pine (*Pinus albicaulis*) is declining nearly rangewide primarily as a result of white pine blister rust, which is caused by the exotic fungal pathogen white pine blister rust (*Cronartium ribicola)*. In the northern Rocky Mountains and Intermountain Region of the United States, recent outbreaks of mountain pine beetle (*Dendroctonus ponderosae*) are also rapidly reducing populations. In these regions, losses are compounded by a trend towards successional replacement of whitebark pine by shade-tolerant conifers in seral communities. The Whitebark Pine Ecosystem Foundation (WPEF) advocates rangewide surveys and monitoring of blister rust infection levels and other mortality factors for whitebark pine. Information obtained from surveying and monitoring will enable managers to plan and prioritize geographic areas for restoration activities.

Standardized methods were developed by the WPEF in 2003 and revised in 2005 to quantify blister rust infection levels, damage, and mortality, and mortality from other factors, including mountain pine beetle spatially and temporally. Recognizing limits to personnel, time, and budgets, we designed these methods to gather critical information efficiently, with minimal technical training. Methods were developed after reviewing 10 major whitebark pine surveys of blister rust incidence, followed by discussion with resource managers, forest ecologists, and pathologists. Meaningful variables were identified as survey objectives, and are recommended for general use in these or similar survey methods. In June, 2003, we conducted a two-day methods field trial on Sawtell Peak, Caribou-Targhee National Forest, Idaho, with 11 participants, including pathologists, managers, and ecologists, representing different experience levels with blister rust surveys (Fig. 1).

The WPEF developed a methods package/database system in collaboration with David Pillmore and Brent Frakes (Rocky Mountain Network Inventory and Monitoring, USDI National Park Service) called the “White pine blister rust survey database: whitebark pine application,” Beta Test Version 2.0. This database is available at no cost from Rocky Mountain Network Inventory and Monitoring, USDI National Park Service, Ft. Collins, CO and can be accessed through a link on the WPEF website (www.whitebarkfound.org) under "Resources". It is a Microsoft Access-based system that stores collected data and calculates summary statistics for plots. This package also interfaces with the Whitebark-Limber Pine Information System (WLIS, developed by the USDA Forest Service, Northern Region, Forest Health Protection, Forest Health Technology enterprise Team, ver. 1.0, March 2006).

Fig. 1. Two-day methods "run-through" in 2003 on Sawtell Peak, Caribou-Targhee National Forest, Idaho, with pathologists, managers, and ecologists from the U.S. and Canada.

In June, 2004, eighty participants from across the range of whitebark pine were trained in the use of the WPEF methods at a workshop held in West Yellowstone, Montana, USA. The training session and ensuing discussion provided feedback enabling further refinement of the methods. In addition, the methods were used in 2003 by C. M. Smith for an extensive assessment in the Canadian Rocky Mountains, providing additional feedback. The revised survey methods are posted on the WPEF website under "Monitoring"

Here, we briefly describe sampling objectives, design, strategy, and key factors concerning the methodology. First of all, when a project is identified, sampling approaches must be determined in advance, with good rationale. The two alternative approaches are "statistical," which uses a GIS-based, randomized or methodical sampling regime designed in consultation with a statistician, or "relevé," in which sampling locations are selected based on predetermined criteria by the field crew. The statistical approach should be used when data must be compared using rigorous statistical assumptions and procedures across space and time, but it may require more funding, personnel, and time resources. The relevé approach is used when documentation of ecological changes is more important than statistically valid estimates of change, and resources are limited. Plots are placed in a representative portion of the sample stand, and the only valid statistical comparisons are between the same plots over time.

Our survey approach is based on a fixed area monumented belt transect plot that is 10 m wide by 50 m in length (500 sq m). Besides detailed geospatial information, the transect description includes: slope, aspect, successional status, habitat or cover type, estimated proportion of each tree species in the overstory, woody and herbaceous plant dominants, and potentially rust resistant candidate trees. Each live or dead whitebark pine tree that is >1.4 m in height within the plot is permanently marked with a sequentially numbered aluminum tag, and the diameter at breast height (DBH) is recorded. Monumenting and tagging ensures that plots can be easily relocated and the same trees resampled to determine change over time. Dead trees are assessed for cause of death; and, each living whitebark pine tree is assessed for blister rust symptoms, canopy kill, bark-stripping, mountain pine beetle infestation, and assigned an overall health status. Blister rust cankers are described as active (sporulating, with new or old aecial spore sacs) or inactive, and recorded for both stem and branch. For branches or stems that appear to have a canker but show no aecial sacs, we recommend that three of five ancillary symptoms be present near the affected area before the canker is identified as definitely caused by blister rust: foliage flagging, rodent chewing/bark stripping, oozing sap, roughened bark, and swelling. Living whitebark pine seedlings <1.4 m in height are counted in the understory survey and further subdivided into two height classes. Active and inactive cankers are recorded for each single stem or clump.

We suggest a number of optional variables which are useful for specific research questions or for obtaining a more detailed picture of either the habitat type or dynamics of spread of blister rust. These variables include: counting stem and branch cankers, counting and identifying species of *Ribes* in the plot, detailed surveys of regeneration (focusing on seedlings and saplings and excluding suppressed trees), identifying other forest trees, and obtaining whitebark pine ages.

Plot data are easily entered into the Access database. Basic summary statistics, such as percentage of live trees with active blister rust stem cankers, are easily calculated for the plots using database queries. If these standardized methods for surveying and monitoring are widely adopted, collected data will provide critical information that can be used for geographic and even temporal comparisons. Such comparisons will provide the tools for managers to prepare regional and even range-wide strategies for whitebark pine restoration, making the most efficient use of resources.