CHAPTER 16.

Monitoring Plots to Evaluate Spread Characteristics, Stand/Site Attributes, Management, and Disturbance Relationships of Black Stain Root Disease in Douglas-fir Plantations in Northern California

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INTRODUCTION

Black stain root disease, caused by the vascular wilt pathogen *Leptographium wageneri*, is widely distributed in Douglas-fir (*Pseudotsuga menziesii*) on substantial acreages throughout the forests of northern California and western Oregon. As a vascular wilt pathogen, *Leptographium wageneri* kills its hosts by growing within and plugging up the water-conductive tissues of the xylem (Hessburg and others 1995). Symptoms of the disease include the presence of individual or small groups of dead and declining trees with sparse chlorotic crowns, reduced growth, and heavy stress cone crops (fig. 16.1). Basal resinosis is another common symptom. The most common diagnostic sign of the disease is a dark brown to purple-black stain in the sapwood of infected roots and lower stems (fig. 16.2).

Although black stain root disease is the most prevalent forest disease of Douglas-fir in northern California (Dale 1995, USDA Forest Service 1994), data on the spread and intensification of the disease are currently lacking. The disease is a management concern not only in commercial second-growth plantations and forests but also on lands that have been designated as late successional reserves (LSRs) under the President's Northwest Forest Plan. Douglas-fir plantations on the Happy Camp Ranger District of the Klamath National Forest provide a representation of the disease situation in many areas of the region. In a 1993 black stain root disease detection survey performed throughout the district, 156 of 1,151 surveyed stands were found to contain infection centers. In 1996, 30 of these stands were randomly selected for intensive survey through the installation of transects and permanent monitoring plots. The transects and plots were remeasured in 2000–2001. In 2012, plans were initiated to commercially thin several of the stands. Because this provides an excellent opportunity to track and compare the distribution and impacts of black stain root disease in thinned and unthinned stands, a new project was initiated to collect

Figure 16.1—Dead and dying Douglas-fir with black stain root disease. (photo by Pete Angwin, U.S. Department of Agriculture, Forest Service)

Figure 16.2—Dark sapwood stain associated with black root disease. (photo by Pete Angwin, U.S. Department of Agriculture, Forest Service)

pre-treatment baseline data to track and compare these impacts. Objectives of the study were to (1) continue the establishment and remeasurement of transects and permanent plots to track black stain root disease incidence and impacts on the Happy Camp Ranger District of the Klamath National Forest, and (2) provide pre-thinning baseline data for a comparison of how management and site disturbance affects the incidence and impacts of black stain root disease in Douglas-fir plantations in northern California.

METHODS

In 2013 and 2014, transects and monitoring plots in the 30 previously surveyed stands were remeasured and remonumented. Three of these stands are due to be thinned. Thinning will be done to a 30- to 35-foot spacing with a feller-buncher and rubber-tired skidder, leaving approximately 60 trees per acre. Remonumenting was done by taking GPS readings of all transect end points, infection centers, and plots, from which GIS maps were constructed. In 2014, a new paired plot survey was initiated to enable a more detailed analysis of the influence of this practice on the spread rate of the disease. For this paired plot survey, new, larger plots were established in pairs in 14 stands that are due to be thinned. Because only three of the previously surveyed stands are due to be thinned, paired plots were established in 11 additional new stands that will be thinned. These stands were identified as infested in the 1993 black stain root disease detection survey but had not been surveyed further. Because the stands lacked transects and smaller monitoring plots, however, installation of these was initiated in 2014 so that none of the thinned stands would lack the full complement of monitoring plots. Fires on the Klamath National Forest interrupted the installation of these plots, leaving four stands to be completed. This portion of the project will be completed in 2015.

The installation of plots in 11 new stands expands the monitoring network to 41 stands, 14 of which will be thinned and 27 of which will not. Locations of the stands are shown in figure 16.3. The data taken in the current pre-thin survey provide a baseline for

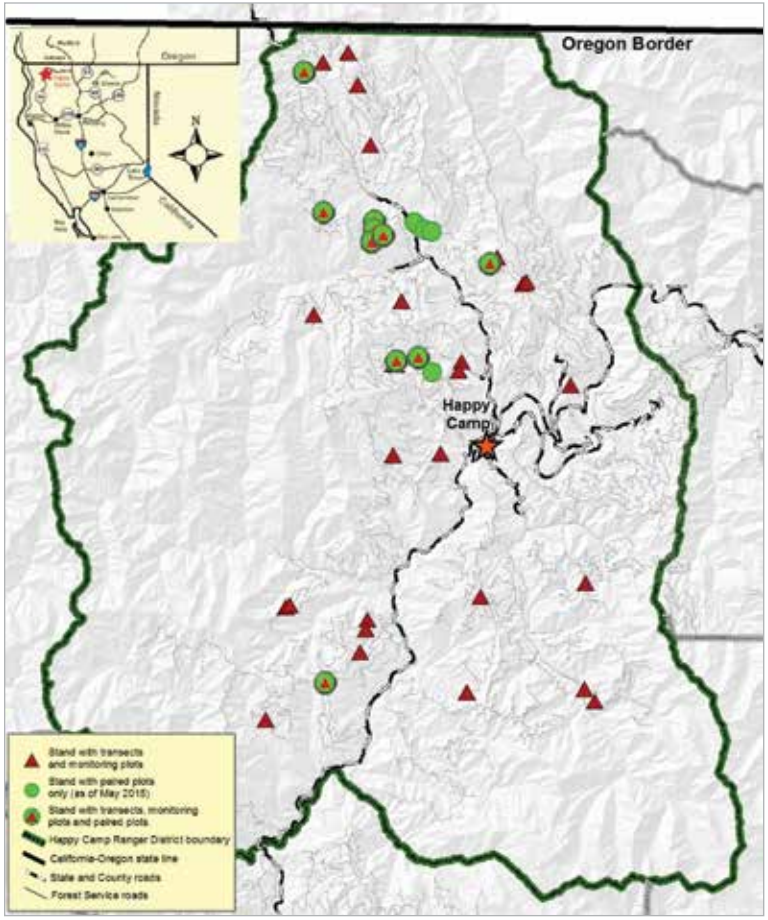

Figure 16.3—Location of black stain root disease monitoring plots on the Happy Camp Ranger District, Klamath National Forest.

the tracking of growth and disease impacts between measurement periods and between thinned and unthinned stands. Post-treatment evaluations will occur shortly after the thinning is completed, with periodic remeasurements every 5–10 years. The layout of transects, monitoring plots, and paired plots within a stand is illustrated in figure 16.4, and the surveys were run as follows:

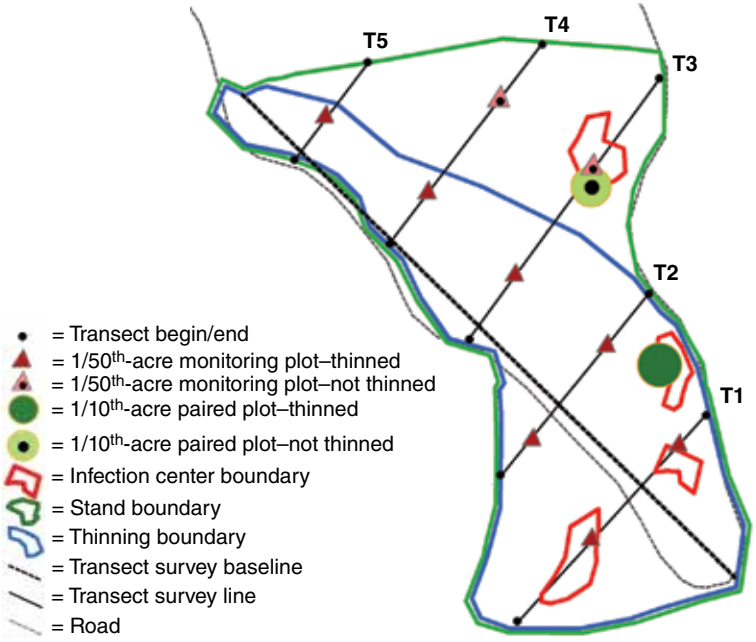

Figure 16.4—Layout of thinning treatment, transects, monitoring plots, and paired plots in a forest stand on the Happy Camp Ranger District, Klamath National Forest.

Transect Surveys

Parallel transect lines were run three chains (198 feet) apart, perpendicular to a baseline located along the longest axis of the stand. Whenever a black stain root disease center was encountered, GPS readings of its location were taken and its length and width were estimated. Perimeters of larger, more irregularly shaped infections were mapped with a GPS for more accurate size estimates. Infection center boundaries were defined by the inner faces of the first healthy-appearing host trees along the margin.

Monitoring Plot Survey

Along each transect, 1/50th-acre circular plots were established in three-chain intervals. In each plot, the number of conifer trees larger than 1 foot in height of each species was counted and recorded, as well as the height, diameter at breast height (d.b.h.), crown condition class, and the number of black stain root disease-infected Douglas-fir. Similar counts were made of standing and downed Douglas-fir. Basal area of the live trees was also measured at each plot center with a Basal Area Factor (BAF)-15 prism.

Paired Plot Survey

Twenty-three sets of 1/10th-acre paired plots were established in the 14 stands that will be thinned. In several stands, more than one plot pair was installed. Each plot pair had similar age and structure and was placed over the advancing edge of an active infection center, allowing the movement of the disease front to be tracked. When the thinning treatment is implemented, portions of these 14 stands will be excluded from thinning so that each plot pair will consist of one thinned and one unthinned plot. Data collected were similar to those on the monitoring plots, with the addition of basal area measurements of all live Douglas-fir, all live and standing dead Douglas-fir, all live trees of all species, and all live and standing dead trees of all species.

Data Analysis

Data analysis is ongoing, comparing both plot and transect survey data taken between measurements. Thinned and unthinned comparisons will compare treated and untreated units and pre- and post-thin measurements. In particular, the paired plots will enable a paired t-test analysis of statistical significance of differences in black stain root disease-caused mortality rates between thinned and unthinned plots and between measurements.

RESULTS

As expected, black stain root disease was found only in Douglas-fir. The disease was present in closely spaced conifers as well as in more open-grown trees. In general, symptoms in individual infected trees became worse between 2000–2001 and 2013–2014. Trees with thinning crowns became chlorotic, chlorotic trees died and became snags, and many snags became downed logs. Most infection centers increased in size between the measurements. However, some small infection centers showed no signs of further expansion, even to immediately adjacent healthy Douglas-fir. Even though infection centers appeared to be expanding, most were still

fairly small. In the current survey, 80 percent of the infection centers were less than 1/10th acre in size, 9 percent were between 1/10th and 1/4th acre, and 11 percent were larger than 1/4th acre. Though not directly measured, we estimated that active infection center edges expanded at a rate of roughly 1 foot per year.

DISCUSSION AND CONCLUSIONS

As stated above, the installation of plots in 11 new stands expands the black stain root disease monitoring network to 41 stands, 14 of which will be thinned, and 27 of which will not. The stands are representative of conditions in young second-growth Douglas-fir in northern California and beyond. Most of the stands in this study were originally old growth that was clear-cut in the 1960s, 1970s, and 1980s. Most were logged with ground-based equipment, though some on steeper ground were cable logged. *L. wageneri* was likely present at low endemic levels in the living trees in the old growth stands. Disturbance, as well as altered stand composition and environment most likely resulted in increased disease intensity and distribution in the second-growth stands. Although exact cause-and-effect relationships are often difficult to identify, field observations indicated positive correlations between the disease and the percentage of Douglas-fir in the stands, clay soils, gentler slopes, and past logging with ground-based equipment. Although black stain root disease caused the death of many individual Douglas-fir trees, expansion of infection centers was relatively slow, allowing the uninfested portions of the stands to grow as fast, large, and healthy as permitted by site quality. However, transport of the pathogen by insect vectors can easily cause more rapid disease spread, and any factors that favor the vectors can increase this spread. Data from these plots will continue to identify which environmental variables and management practices affect the spread and intensification of the pathogen and to what degree. Establishment and measurement of plots prior to commercial thinning has provided a baseline for the tracking of forest growth and disease impacts in treated and untreated stands. In addition, the paired plots will clarify the relationships between thinning and disease spread and intensification. The data will also be used for the validation and calibration of root disease models for the range of stand conditions in Region 5.

CONTACT INFORMATION

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