

Five Years of Monitoring Infection and Mortality in Redwood Tanoak Forests¹

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Abstract

Rates of disease incidence and tree mortality in redwood-tanoak forests were determined by repeated sampling across a system of 120 plots at five long-term research sites from 2001 through 2006. Plots were located within the known geographic area of *Phytophthora ramorum* in California, ranging from Monterey to Sonoma counties. All overstory species were monitored, but analysis was restricted to three important host species: California bay laurel (*Umbellularia californica*), tanoak (*Lithocarpus densiflorus*), and redwood (*Sequoia sempervirens*). Infection in bay laurel and tanoak varied among years and plots suggesting weather patterns and abundance of susceptible species are important determinants of disease dynamics. Disease incidence was greatest in bay laurel followed by tanoak and redwood. Tanoak stems greater than 10 cm diameter at breast height were killed more frequently than smaller trees. Further analysis will use statistical modeling and validation to evaluate the role of vegetation structure and climate variation on rates of infection and mortality of tanoak. By proving baseline rates of infection and mortality across structurally heterogeneous stands, this effort will help in the design of stand-level management strategies and identification of local areas where control strategies will be most effective.

Key words: Long-term monitoring, infection rates, mortality rates, changes in forest composition.

Overview of Study

Long-term monitoring is necessary to understand the consequences of stand infestation by *Phytophthora ramorum* and the subsequent ecological impacts of sudden oak death. Management efforts require an understanding of infection rates for major overstory species, rates of mortality of susceptible species, and proportional changes in species composition. Management efforts in *P. ramorum* infested forests are currently operating without empirically defined rates of mortality and infection. To develop long-term systematic management plans for California forests we should have a strong modeling framework that allows us to predict the spread and intensification of the pathogen on individual sites, target the most effective control treatments, and evaluate the effectiveness of these treatments. To date, most

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modeling of *P. ramorum* spread has focused on mapping areas at risk and spatial modeling of susceptible-infectious transitions (Hunter and others, this proceedings) however, better understanding at the stand level is needed to evaluate eradication treatments, focus future eradication efforts, and design other stand level management. This study examines stand-level rates and patterns of *P. ramorum* infection in redwood-tanoak forests.

Over the course of five years, 120, 500 m² study plots located at five sites were visited annually and monitored for infection and mortality. The study design was somewhat unbalanced with 30 plots at Jack London State Park (Sonoma County) and the Marin Municipal Water District (Marin County), and twenty plots at two sites in Big Sur and two sites in Santa Cruz County (See Maloney and others 2005 for further site information). During the initial survey, all overstory stems greater than 1 cm diameter at breast height (DBH) were measured in each plot. Foliage subsamples (about 3 g) from all trees with tissue symptomatic of *P. ramorum* were removed and returned to the laboratory where *P. ramorum* infection was confirmed by growing colonies on a *Phytophthora* selective media (PARP). High disease incidence was found in bay laurel and tanoak during the initial survey (Maloney and others 2005). In subsequent years, five trees of each overstory species were randomly selected and assessed for infection status. New infections were confirmed by the method described above. Plot level mortality was estimated by randomly selecting five infected trees and assessing their mortality status. Climate factors including precipitation and temperature have important control over levels of *P. ramorum* sporulation (Davidson and others 2005). The influence of climate factors on infection rates were explored with Poisson regression for each overstory species using a categorical descriptor of proportional increase in infection (0 to 5) as the dependent variable and daily precipitation, maximum, and minimum temperature derived from a regional model (Hunter and Meentemeyer 2005) as independent variables. A separate multiple linear regression evaluated cumulative incidence of infection of each overstory species as the dependent variable and tree density of each focus species as independent variables (three species in each model).

Summary of Results

Cumulative proportion of infected trees steadily increased over the course of the five year study period. Of the plots with known infection by *P. ramorum*, disease incidence was greatest in California bay laurel at 90 percent of surveyed trees. Incidence was 80 percent for tanoak and 20 percent for redwood. Disease incidence rate slowed for bay laurel as infection approached 100 percent. Poisson regression analysis revealed positive effects of precipitation in April and May, and negative effects of maximum temperature on temporal patterns of tanoak infection. Year-to-year differences in redwood infection were negatively related to maximum temperature. Plot level estimates of infection incidence of tanoak and redwood were significantly related to density of bay laurel at the plot level.

Cumulative tanoak mortality increased gradually over time. By the end of measurements, proportional tanoak mortality showed exponential increase consistent with the observed logistic pattern of infection. Large diameter tanoak appear to have greater incidence and rate of mortality compared to smaller diameter trees. Within these study plots, tanoak mortality has resulted in an average 40 percent reduction in

tanoak basal area and at current rates, dead tanoak basal area will exceed live basal area in the next five years. Tanoak mortality has resulted in approximately 2.5 percent increases in relative basal area of both redwood and bay laurel. Very little mortality of redwood and bay laurel occurred during the measurement period and observed mortality was not associated with tree or plot infection status suggesting that *P. ramorum* is not a significant cause of mortality in bay and redwood at the five year timescale of this study.

The sites monitored in this study are representative of many infested stands in central California with respect to composition and impacts (See Murphy and others this proceedings). *Phytophthora ramorum* and subsequent impacts of the disease sudden oak death have spread rapidly through these infested forests and resulted in loss of tanoak. Rate of disease spread is alarming and is likely to subsequently impact ecosystem processes that determine rates of nutrient turnover, input of fine and course woody debris, and overstory community composition. Stand level manipulations should be undertaken with recognition that specific recommendations are not possible based on the current state of knowledge and lack of long-term empirical data for forests other than redwood tanoak.

Literature Cited

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