

Influence of Oak Woodland Composition and Structure on Infection by *Phytophthora ramorum*¹

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Abstract

Introduced plant pathogens have major ecological impacts in many parts of the world. While the spread of pathogens can be strongly mediated by the composition and structure of local host plant communities, little is known about effects of plant community structure on invasion dynamics of introduced pathogens. The progress of infection by the invasive pathogen *Phytophthora ramorum* in coastal California woodlands varies greatly among localities, and some of this variation might be explained by local variation in tree species composition and forest structure. The degree to which patterns of *P. ramorum* infection depend on the abundance and type of host species present was examined in 202 randomly located plots within a 275 km² region in eastern Sonoma County, California.

The abundance of over- and understory woody species was measured in plots established in 2003. The disease severity of *P. ramorum* in these plots were surveyed in 2004, 2005, and 2006 through timed counts of symptomatic leaves on bay laurel (*Umbellularia californica*), the primary producer of inoculum in mixed oak woodlands. Leaves were collected and cultured from each plot to confirm presence of *P. ramorum*. Presence of canker infections on oak and tanoak hosts were visually assessed. The among-year repeatability of our censuses of symptomatic bay laurel leaves was confirmed through linear regression of square-root transformed values of the number of leaves counted in spring 2005 compared to spring 2006. These analyses revealed that 74 percent of the variation in 2006 symptomatic leaf count was explained by the 2005 leaf counts. The two-year average value is used in all subsequent analyses.

Bay laurel was the most widely distributed woody species, occurring in 97 percent of plots, followed by coast live oak (*Quercus agrifolia*) (72 percent), Douglas-fir (*Pseudotsuga menziesii*) (47 percent), black oak (*Quercus kelloggii*) (45 percent), madrone (*Arbutus menziesii*) (43 percent), Oregon white oak (*Quercus garryana*) (43 percent), and toyon (*Heteromeles arbutifolia*) (41 percent). The considerable variation in vegetation composition across the study area and high replication of plots also allowed for assessment of the influence of host composition on levels of *P. ramorum* infection. Specifically, the assessment determined whether higher levels of symptomatic bay tissue increases the probability of oak

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infection in a plot and if the presence of oak species is associated with lower numbers of symptomatic bay leaves.

The results showed that bay laurel trees were infected more frequently than canker hosts throughout the study area. Symptoms of *P. ramorum* were observed on bay laurel in 89 percent of plots where it was present, with every stem symptomatic in one third of the plots. In contrast, only nine percent of coast live oak stems were symptomatic in the 123 plots where it occurred, and only six percent of black oak stems were symptomatic in the 80 plots where it occurred. In the 37 plots where oak trees with cankers occurred, 80 percent of bay laurel stems exhibited symptoms of *P. ramorum*, whereas only 26 percent of oak stems possessed symptoms. Overall, oak stems with cankers were observed throughout the study area, but most of them were found in the southwestern portion of the study area, the region believed to be first exposed to the pathogen. The probability of symptomatic coast live oak trees in a plot was positively related to the number of co-occurring symptomatic bay laurel stems.

Plots containing coast live oak ($n = 74$), black oak ($n = 38$), both oak species ($n = 32$), and no oak species ($n = 36$), were compared using an analysis of variance to determine if the presence of oak canker hosts is negatively related to number of symptomatic bay leaves (using only plots where bay laurel was present). Number of symptomatic bay laurel leaves was significantly lower in plots where coast live oak was present than in plots where it was absent. In addition, number of symptomatic bay laurel leaves was negatively related to the number of coast live oak stems. In contrast, presence of black oak was not related to the number of symptomatic bay laurel leaves. Finally, strong positive relationships between the number (or proportion) of bay stems and total (or mean) number of symptomatic bay leaves were observed, and these relationships did not depend on the presence or absence of oak species.

Taken together, these results suggest that *P. ramorum* spreads among bay laurel in advance of infection on canker hosts, which emphasizes the important role this foliar host plays in the establishment of *P. ramorum* in oak woodlands. The relationship between oak density and disease severity in bay laurel may arise from two possible mechanisms. If disease intensification in bay laurel is density dependent, disease should be lower where the density of bay laurel stems is lower, for example in plots with higher numbers of oak stems. On the other hand disease establishment in bay laurel may be lower in oak dominated plots because these sites are generally warmer, drier habitats not as suitable for *P. ramorum* growth and survival. Further research will distinguish the relative importance of these alternatives.

Key words: Tree species composition, Sonoma County, plant community structure.