

Incidence of *Phytophthora ramorum*, *P. nemorosa* and *P. pseudosyringae* in Three Coastal California Forest Communities¹

Shannon K. Murphy² and David M. Rizzo²

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Abstract

Phytophthora ramorum is well established over approximately 450 km of forests along the California coast. In the course of research on this emerging pathogen, two other aerial species of *Phytophthora*, *P. nemorosa* and *P. pseudosyringae*, were discovered. Little is known about the ecology and biology of these other species and how they interact with *P. ramorum*. Preliminary research has found that *P. nemorosa* and *P. pseudosyringae* have similar host and geographic ranges and cause similar disease symptoms as *P. ramorum*. However, *P. nemorosa* and *P. pseudosyringae* do not appear to cause landscape level mortality of oaks (*Quercus* spp.) or tanoak (*Lithocarpus densiflorus*), as does *P. ramorum*. These three species are virtually indistinguishable in the field and can only be identified microscopically.

A plot study was established to determine the distribution and incidence of *P. ramorum*, *P. nemorosa* and *P. pseudosyringae* in coastal forest communities, and to relate pathogen presence to community, structural and environmental variables. A total of 120 circular, 500-m² plots were established at ten sites within the known range of *P. ramorum* in Alameda, Contra Costa, Marin, Mendocino, Napa, Santa Cruz, and Sonoma counties. Field plots were installed during the summer months of 2001 and 2002 and re-sampled in the spring and summer of 2004. Six of the sites were in California state parks, three were in county or regional parks, and one was on private property. Three native forest communities were surveyed: coast redwood (redwood), and two associations of the mixed-evergreen forest, oak-bay-madrone (oak) and tanoak-madrone-live oak-Douglas-fir (tanoak) forests. Each of these forest communities contain numerous hosts of *P. ramorum* and at least two hosts of *P. nemorosa* and *P. pseudosyringae*. California bay laurel (*Umbellularia californica*) was the only plant species that occurred in all of the forest communities surveyed. Plots were located along elevational transects proceeding perpendicularly from river valleys toward ridge tops, with three independent plots along four transects at each site, placed in a stratified random design. Transects were selected to represent a variety of aspects and native plant community types, areas with minimal human disturbance, and randomly sampled for *Phytophthora* species. Each plot was evaluated for plant species composition,

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² Department of Plant Pathology, University of California, Davis, CA 95616; (530)754-9894; corresponding author: skmurphy@ucdavis.edu

forest structure and environmental variables, and incidence of aerial *Phytophthora* species. A total of 5105 trees and shrubs were mapped and examined for *Phytophthora* species.

Based on the two sampling periods, *P. ramorum* was recovered from 29 percent of plots at seven sites, *P. nemorosa* from 9 percent of plots at four sites and *P. pseudosyringae* from 9 percent of plots at three sites (table 1). *P. ramorum* and *P. nemorosa* were found together at three sites, on eight plots, and were both isolated from the same California bay tree 16 times and from coast redwood (*Sequoia sempervirens*) one time. *P. ramorum* coexisted with *P. pseudosyringae* at two sites, on three plots, and with one co-occurrence on a California bay tree at Austin Creek State Park. *P. nemorosa* and *P. pseudosyringae* were not recovered together on any plots. All three *Phytophthora* species were detected at one site, Redwood East Bay Regional Park. At Big Basin State Park, no *Phytophthora* species were recovered in either sampling year. Interestingly, this is the only site where there was no California bay laurel present, from which we can postulate that bay is a key component to explain presence of these *Phytophthora* species.

We found that the three *Phytophthora* species occupied similar ecological niches; they overlap in geographical range, forest community presence, and host range. A Pearson chi-square test analyzed associations of the pathogens with the forest communities. Each of the pathogens was positively associated with a specific community type: *P. ramorum* with the tanoak community, *P. nemorosa* with the redwood community, and *P. pseudosyringae* with the oak community. Although each *Phytophthora* species occurred more often with a particular forest community than would be expected if they were independent, it is important to recognize that both *P. ramorum* and *P. nemorosa* were found in all three forest types. These findings are consistent with observed sampling patterns by other studies (Davidson, J.M. unpublished data; Jensen, C.E. unpublished data; Wickland and Rizzo 2005; Maloney and others 2005).

Generalized Additive Modeling (GAM) was used to explore how ecological variables may contribute to pathogen presence in this study. As with previous studies, increased cover of bay was found to increase the probability of *P. ramorum* occurrence; a similar relationship with California bay laurel was noted for *P. nemorosa* and *P. pseudosyringae*. GAM substantiated the association analysis that predicted a high probability of *P. nemorosa* with the redwood forest type and *P. pseudosyringae* with the oak community. The model additionally predicts *P. ramorum* presence to be greatest at locations close to the coast, close to a river or creek, and in forests with high total basal area. There was limited recovery of *P. nemorosa* and *P. pseudosyringae* ($n < 30$) so results for these pathogens are exploratory rather than statistically rigorous. However, the results are biologically plausible and consistent with observations made by other researchers.

Results from this study provide additional information about the distribution of *P. ramorum*, including examination of location and intensity of sudden oak death within state and regional parks, and within East Bay counties where *P. ramorum* plots had not previously been established. This is the first study to examine the ecological associations between these three *Phytophthora* species, across a wide geographic distribution and within several forest communities. Future research will continue to monitor spread of the pathogens within these plots, as well as further examine ecological relationships with these three pathogens using a larger data set.

Table 1- *Phytophthora* species detection at all sites.

Site	County	<i>Phytophthora</i> Species ¹		
		Pr	Pn	Pps
Boonville Property	Mendocino	+	-	-
Salt Point SP	Sonoma	-	+	-
Austin Creek SP	Sonoma	+	-	+
Armstrong Redwoods SP	Sonoma	+	-	-
Skyline Regional Park	Napa	+	-	-
Mt. Tamalpais SP	Marin	+	+	-
Briones EBRP	Contra Costa	+	-	+
Redwood EBRP	Alameda	+	+	+
Big Basin SP	Santa Cruz	-	-	-
Henry Cowell SP	Santa Cruz	+	+	-

¹Pr= *Phytophthora ramorum*; Pn= *P. nemorosa*; Pps= *P. pseudosyringae*

References

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