

# Susceptibility to *Phytophthora ramorum* in California Bay Laurel, a Key Foliar Host of Sudden Oak Death<sup>1</sup>

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## Abstract

Sudden oak death, caused by the water mold *Phytophthora ramorum*, is a plant disease responsible for the death of hundreds of thousands of oak and tanoak trees. Some foliar hosts play a major role in the epidemiology of this disease. Upon infection by *P. ramorum*, these foliar hosts express non-fatal leaf lesions from which large amounts of inoculum can be produced and spread to neighboring host individuals, including oak species. *Umbellularia californica* (California bay laurel) may be one of the most important foliar hosts of sudden oak death due its observed ability to produce inoculum and its high abundance in the woodlands of coastal California. While previous research on susceptibility to *P. ramorum* in *U. californica* has shown significant variability among trees, with more resistant individuals in northern areas of its range, little is known about the causes or extent of this variability. Here, we ask three research questions: (1) How does susceptibility vary among *U. californica* individuals and *P. ramorum* isolates? (2) Are *U. californica* phenotype and genotype related to susceptibility? (3) What factors influence disease expression in nature?

We conducted lab susceptibility trials on detached leaf samples and assessed field symptom levels for 97 *U. californica* trees from 12 plots, four from each of three regional clusters, in a 275 km<sup>2</sup> area in Sonoma County, California. In each plot, field disease expression was quantified using 90 second timed counts of the number of symptomatic leaves. For each tree,

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leaves were collected for laboratory analysis of AFLP (amplified fragment length polymorphism) molecular markers, leaf toughness, water content, and susceptibility. Susceptibility trials were conducted by inoculating leaves with two *P. ramorum* isolates and scoring resulting lesion size. Within a GIS, latitude and longitude, elevation, topographic moisture index, and annual precipitation were calculated for each plot. In addition to the 97 Sonoma county trees, leaves for susceptibility trials were also collected from five trees from a high oak mortality reference site in Marin County.

We found that susceptibility varied significantly among *U. californica* trees, with a five fold difference in lesion size. The Marin County individuals developed significantly larger lesions, but significant differences were not found among the 12 plots in Sonoma County. The phenotypic trait of leaf area was significantly related to lesion size, where bigger leaves produced bigger lesions. The two different isolates produced similar sized lesions.

We found variability in lesion size produced on detached leaves was significantly related to six AFLP markers (loci were screened using a series of one-way ANOVAs; each of the six loci were significantly related to lesion area at  $P < 0.05$ ), suggesting a genetic basis to resistance. Molecular marker analysis also revealed genetic structure in this species was partitioned significantly within plots, among plots, and among plot clusters, but the greatest diversity levels were found within plots. Variation in field symptom levels was significantly different among plots and primarily correlated with environmental site conditions, including longitude, topographic moisture index, mean precipitation, and mean daily temperature minimum. There was no relationship between lesion size produced in the laboratory and symptomatic leaf count in the field, suggesting that local environmental conditions influence disease expression in nature more than genetic or phenotypic host factors, at the scale of this study.

This work demonstrates that susceptibility to *P. ramorum* in *U. californica* depends on genetic, phenotypic, and environmental characteristics, as well as *P. ramorum* isolate virulence, and provides useful information for predicting spread risk among *U. californica* and onto oak trees.

A more detailed account of this work can be found in the subsequent journal publication: Anacker, B.L.; Rank, N.E.; Daniel Hüberli, D.; Garbelotto, M.; Gordon, S.; Harnik, T.; Whitkus, R.; Meentemeyer, R. 2007. Susceptibility to *Phytophthora ramorum* in a key infectious host: landscape variation in host genotype, phenotype, and environmental factors. *New Phytologist*. doi: 10.1111/j.1469-8137.2007.02297.x.

Key words: *Umbellularia californica*, California bay laurel, *Phytophthora ramorum*, sudden oak death, disease susceptibility, sporangia, amplified fragment length polymorphism (AFLP).