

Residual Tree Response to Tanoak Decline in California¹

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Abstract

Coast redwood (*Sequoia sempervirens*) frequently grows in association with tanoak (*Lithocarpus densiflorus*) along the central and northern California coast. High rates of tanoak mortality beginning in the mid 1990's have been attributed to *Phytophthora ramorum*, a water mold believed to be non-native. Of the many species that host *P. ramorum*, tanoak is one of the most susceptible and thousands of tanoak trees have died in the past ten years. In a two species forest, the implications of losing one species may be severe, especially when one species is a mast producer such as tanoak. These trees provide numerous ecological benefits, many of which have yet to be quantified. Tanoak has long been classified as a weed by the timber industry because of its ability to colonize and re-sprout following disturbance. For this reason, tanoak is frequently the target of vegetation control treatments using herbicides to reduce competition with the commercially valuable redwood trees. Tanoak does have considerable ecological value as the only mast-producing species in redwood/tanoak forests. Development patterns in redwood/tanoak forest stands have not been quantified, nor has the response pattern of residual trees following invasion of a stand by *P. ramorum*. The objectives of this study were to quantify stand development patterns in redwood/tanoak stands, assess residual tree response to tanoak decline and mortality, and develop guidelines for restoration and management of affected stands.

Two study areas were utilized: one currently exhibiting high rates of tanoak mortality from *P. ramorum* and a second site outside the current range of *P. ramorum* infection and exhibiting background rates of tanoak mortality. The infected site was located on the Marin Municipal Water District, Marin County where four stands were selected for sampling. Three stands were selected on Jackson Demonstration State Forest, Mendocino County, which is currently uninfected. All stands were similar in age and species composition. Three circular, fixed plots

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between .01 and .10 hectare in size were installed in each stand. For each tree, species, diameter and location were recorded. Between six and 10 “sample” trees were then selected for more intensive data collection, including total tree height, live crown length, crown radii, sapwood area, age and growth rates. Trees were either cored or felled for stem analysis to obtain data for height/age development patterns. Leaf area was estimated for each redwood sample tree using an equation developed by the silviculture laboratory at the University of California, Berkeley. Calculations of crown surface area for redwood used a paraboloid shape and a hemispherical shape for tanoak. Redwood basal area growth was calculated in a subset of the data for two time periods and compared: pre- and post- *P. ramorum*. A second set of comparisons was made assuming a 2-year lag time between tanoak mortality and redwood response.

Stand development patterns at both sites were similar: even-aged stands with redwood stratifying above the tanoak. This pattern appears early in stand development and tanoak continues to hold a sub-canopy position as the stand ages. Approximately 50 years into stand development, some of the redwood trees begin falling behind in height growth and join the tanoak in the lower canopy layer as the lagging redwood slow in growth and the tanoak maintains a more steady growth rate. Redwood sample trees at each site showed a similar relationship between leaf area (m²) and diameter at breast height (1.37m). However, sample trees from Marin County had higher crown surface area (m²) than trees from Mendocino County. While this difference may be due to stand density, neither trees per hectare nor basal area per hectare were significantly different between sites ($p > 0.05$). Basal area growth trends showed typical age-related decline at both sites for the post-*P. ramorum* time period and rates were similar between sites. However, when basal area growth was compared using a time lag between tanoak mortality and redwood response, only the Mendocino non-infected site showed the expected age-related decline. However, these differences were small and not significant ($p > 0.05$). Overall, Marin County trees showed a trend toward greater basal area growth in addition to the greater crown surface area. The reasons behind greater growth could be attributed to several factors, including the beginning signs of individual tree response to tanoak decline. While the sites are similar, they are removed from each other by approximately 130 miles. It is possible that the differences observed thus far in the analysis are due to a difference in site such as soil moisture. Additionally, redwood has unusual tree ring patterns that may result in underestimation of growth rates and age estimates. As tanoak continues to decline in abundance in these stands, a shift in species composition will trend towards single-species redwood forests. In these situations, trees of the lesser canopy classes in addition to codominant trees, are the most likely to respond to increased growing space. Where large gaps are created, less susceptible tree species may regenerate or redwood sprouts may respond through rapid increases in height and diameter growth. Further analysis will

investigate the affect of variable redwood rings on tree age and growth rate measurements, whether crown surface area differs by canopy class and a more in-depth view of tree growth pre- and post- *P. ramorum*.