Relationships between *Phytophthora ramorum* canker (sudden oak death) and failure potential in coast live oak

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We conducted a retrospective study on coast live oak (Quercus agrifolia) bole, large branch, and root failures in woodlands affected by Phytophthora ramorum canker (sudden oak death) to quantify levels of failure in these woodlands and determine how various tree and stand factors are related to failure potential. In fall 2002, we catalogued coast live oak failures in six natural stands in Marin County, California, that had high levels of P. ramorum canker. We noted characteristics of each failure; estimated the date range in which the failure occurred; evaluated the condition of the tree with respect to P. ramorum infection, colonization by Hypoxylon thouarsianum and other decay fungi, beetle boring, and tree defects; and noted stand characteristics in the immediate vicinity of the failure. Nonfailed trees in the stand were used as a control population to identify factors that might contribute to tree failure.

Rates of bole and large branch (>20 cm diameter) failures were significantly higher between about July 2001 and December 2002 than in the period from 1992 through July 2001. Bole failures were the most common type of failure. Based on the estimated date of failure, for the years 1992 through 1996, boles failures occurred in 0.5% of the trees each year. The incidence of bole failures increased to 5% per year between mid-2001 and the end of 2002. Among recent failures (2001-2002), 39% of the bole failures and 30% of the scaffold failures occurred in live stems. The majority of observed root and root crown failures also occurred in live trees.

Among trees with recent failures (2001-2002), 83% showed symptoms of P. ramorum infection. Branch, scaffold, and bole failures were strongly associated with advanced symptoms of P. ramorum canker, which include evidence of wood degradation by H. thouarsianum and/or various wood boring beetles. Early P. ramorum canker symptoms, consisting of only bleeding cankers without secondary invasion, were not associated with an increased likelihood of failure.

Wood decay was the most consistent and important factor influencing failure potential. Decay was present and rated as a contributing factor in almost all failures. Fruiting bodies of H. thouarsianum and other wood decay fungi, decay columns, and canker rot symptoms were significantly more common among failures than among nonfailed controls. Several variables indicative of wood decay were highly significant predictors of failure in both recursive partition and multivariate logistic regression models. Beetle boring was also significantly more common among failures than among nonfailed trees. Other factors associated with increased failure potential include overtopping of the tree by other trees, local alteration of the stand canopy due to dead or failed trees, multiple trunks, multiple branches arising from the same point, and asymmetric canopy shape. Failures in both live and dead trees were largely influenced by the same factors.