

# Quantification of Sudden Oak Death Tree Mortality in the Big Sur Ecoregion of California<sup>1</sup>

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## Abstract

Big Sur is one of the most ecologically diverse regions in California and well recognized as a biodiversity hotspot for global conservation priority. Currently the region is experiencing substantial environmental change due to the invasion of *Phytophthora ramorum*, the plant pathogen causing the forest disease known as sudden oak death. First confirmed in 2000, *P. ramorum* has spread quickly through many canyons in Big Sur killing large numbers of ecologically important oak (*Quercus* sp.) and tanoak (*Lithocarpus densiflorus*) trees with little indication of slowing. Despite these impacts detailed data on the current extent and magnitude of tree mortality are lacking yet critically needed to guide management strategies in both impacted and uninfected forests.

In this study we quantified tree mortality across a 794 km<sup>2</sup> area on the Pacific slope of the Santa Lucia Range in the Big Sur ecoregion. Two primary host habitat types (redwood-tanoak forest; mixed oak woodland, which includes coast live oak, shreve's oak, and black oak) were mapped in a GIS from high-resolution (0.33 m) digital color aircraft imagery collected in 2005. We also used the imagery to detect and map the location of every dead tree that exhibited spectral characteristics of trees killed by sudden oak death within each host habitat type. We evaluated the accuracy of the remote detection mapping by assessing causes of tree mortality in 77 field plots (50 X 50 m, 0.25 ha) stratified by host habitat type, oak mortality level, latitude, and fire history. Intersection of the field and remote assessments in the GIS showed that the remote mapping systematically underestimated the actual number of trees killed by sudden oak death. Tree mortality was adjusted for each host habitat type using regression models that related the field-determined number of *P. ramorum* caused deaths to the density of dead trees detected remotely and local habitat conditions. The models significantly improved remote assessment of oak mortality, with stronger relationships in mixed oak woodlands ( $r^2 = 0.77$ ) than redwood-tanoak forests ( $r^2 = 0.66$ ). Using these field data, we also modeled the amount of dead tree basal area (m<sup>2</sup>) in relation to the density of mapped dead trees in mixed oak woodlands ( $r^2 = 0.73$ ) and redwood-tanoak forests ( $r^2 = 0.54$ ). Application of the regression models in the GIS estimated a total of 235,678 trees (12,650 m<sup>2</sup> tree basal area) killed by *P. ramorum* in the ecoregion, with 63 percent of mortality occurring in redwood-tanoak forests and 37 percent in mixed oak woodlands. Tree mortality of this magnitude and geographic scale has never been reported for sudden oak death. The resulting maps are being used to prioritize management strategies and examine factors driving spatial dynamics of disease spread in the region.

Key words: *Phytophthora ramorum*, forest disease, tree mortality, remote sensing, GIS, landscape epidemiology, Big Sur.

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