

Relationship Between Precipitation and Tree Mortality Levels in Coastal California Forests Infested with Sudden Oak Death¹

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Abstract

Phytophthora ramorum has caused extensive oak (*Quercus*) and tanoak (*Notholithocarpus densiflorus* (Hook. & Arn.) Manos, Cannon & S.H. Oh) mortality in portions of the central and north coasts of California. In conjunction with stream and terrestrial surveys, aerial detection surveys have played a critical role in detection and monitoring efforts associated with sudden oak death (SOD) throughout these regions. Aerial surveys conducted by the U.S. Department of Agriculture Forest Service, Forest Health Protection, have consistently documented the extent and intensity of hardwood mortality across forested areas affected by SOD since 2005. The main objective of this analysis is to determine whether oak and tanoak mortality levels, within regions infested with SOD, are related to precipitation.

Many environmental factors influence the severity of disease epidemics. Precipitation data from weather stations and data from the Palmer Drought Severity Index (PDSI) were used during analysis. Three study areas were included: one in the Santa Cruz Mountains, including portions of San Mateo, Santa Cruz, and Santa Clara Counties; one in the north San Francisco Bay area, including portions of Marin, Sonoma, and Napa Counties; and one in southern Humboldt County. All study areas were known to be infested with *P. ramorum* prior to 2005 based on PCR confirmations by University of California (UC) Davis and UC Berkeley staff. Only locations where aerial surveys occurred every year were included during analysis. Within each study area, total acres with oak and tanoak mortality and estimated numbers of recently killed trees were calculated each year from 2005 to 2011.

Detected tree mortality levels varied among years, but similar trends were found at two of the three study areas. Mortality levels increased from 2005 to 2007, decreased from 2008 to 2010, and increased again in 2011 within both the North Bay Area and in southern Humboldt County. Higher levels of precipitation during the 2 years prior to observed mortality appeared to correspond with higher mortality. Observed mortality levels at these two north coast locations (both number of acres with mortality and number of killed trees) were closely related to mean departure from normal precipitation of the 2 previous years based on linear regression with F-tests (values of $p < 0.05$, R^2 ranged 0.64 - 0.93). Observed mortality levels were also closely related to the mean PDSI value of the 2 previous years (values of $p < 0.05$, R^2 ranged 0.58 - 0.93). The strongest relationships between observed mortality levels and precipitation data were in southern Humboldt County. However, no significant trends were found between precipitation data and aerial survey data collected in the Santa Cruz Mountains area. An exponential relationship also was detected between number of killed trees that were mapped each year and precipitation data in the north Bay and southern Humboldt County areas (after a square root transformation, values of $p < 0.04$, R^2 values ranged 0.64 - 0.75).

Although other factors influence oak and tanoak mortality in coastal regions infested with *P. ramorum*, precipitation seems to be an important predictive factor when estimating annual mortality levels in the North Bay Area and southern Humboldt County. Future weather events that influence precipitation levels, such as drought, El Niño, and La Niña, will likely affect severity of tree mortality associated with SOD throughout coastal landscapes.

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