

# Determining Landscape-Scale Changes in Forest Structure and Possible Management Responses to *Phytophthora ramorum* in the Mt. Tamalpais Watershed, Marin County, California<sup>1</sup>

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## Abstract

The Marin Municipal Water District's (MMWD) 7487 ha Mt. Tamalpais watershed in Marin County, California has the dubious distinction of being one of the earliest and most extensive areas impacted by *Phytophthora ramorum* in California. Rapid die off of tanoaks (*Notholithocarpus densiflorus* (Hook. & Arn.) Manos, Cannon & S.H. Oh) were first documented in 1995. With funding support from the U.S. Department of Agriculture Forest Service, MMWD initiated an assessment of landscape-scale changes in forest structure and understory floristics relative to *P. ramorum* spread in the Mt. Tamalpais watershed. The assessment looked at changes in the extent and severity of diseased stands over a 5-year period as well as changes in understory vegetation. Three specific questions were addressed to support the development of a response strategy: (1) What sudden oak death (SOD)-related changes have already occurred? (2) What future SOD-related impacts are likely, or where is SOD likely to spread? (3) What is the status of natural regeneration in SOD-impacted stands? An additional benefit of this project was revision of the SOD-impacted portions of the 2004 vegetation map for the Mt. Tamalpais watershed to more accurately reflect stand conditions in 2009.

Analysis of true color aerial imagery of the watershed indicated that the spatial extent and severity of SOD-related tree mortality expanded between 2004 and 2009 from 3541 ha to 4330 ha. This represents 83 percent of all habitat on the watershed with a principal component of tanoaks, coast live oak (*Quercus agrifolia* Nee), black oak (*Q. kelloggii* Newb.), canyon live oak (*Q. chrysolepis* Liebm.), or Shreve's oak (*Q. parvula* var. *shrevei* (C. H. Muller) Nixon). The largest un-impacted stand in 2009 was 61 ha in size. In both 2004 and 2009, canopy mortality was most pronounced in tanoak-dominant assemblages in the western Bolinas Ridge portion of the watershed. Much of the expansion between 2004 and 2009 was due to a spatial increase in coast live oak mortality in the southern and eastern portions of the watershed. Type conversions from one recognized vegetation association to another were detected for 840 ha of habitat where tanoak ceased to be a primary component.

Ground sampling identified changes in understory shrub and herbaceous cover relative to disease progression. Shrubs overall showed a 38 percent increase in stands with lessening disease severity, were nearly unchanged in areas where disease severity remained stable, and increased 21 percent in areas where disease severity increased. Evergreen huckleberry (*Vaccinium ovatum* Pursh) increased 19 percent in areas where the SOD severity changed, but decreased 10 percent in moderate to severely infected plots where the disease level remained unchanged. Weedy grasses increased by 143 percent, regardless of SOD severity; native grasses increased 131 percent. Recruitment of replacement species was not observed.

Quantification and mapping of both canopy and understory changes relative to *P. ramorum* infection on the watershed are informing MMWD staff in the assessment of response options. With little un-impacted susceptible habitat remaining, containment or chemical treatment options are unlikely to be meaningful. Initiation of active revegetation remains premature, as continued tree failures hinder access, and likely survival, of plantings.

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