The Big Sur Ecological Monitoring Plot Network: Distribution and impacts of Sudden Oak Death in the Santa Lucia Mountains

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Background

The Big Sur area is one of the most ecologically diverse regions in California. Land preservation efforts are well established in Big Sur, including numerous preserves, state parks and the Los Padres National Forest. It appears that no manner of preservation has been able to protect these wild areas from conservation threats such as exotic species (plants, animals, and pathogens) and alterations of key natural processes such as fire. Big Sur has provided an exceptional environment to address questions about the ecological ramifications of *Phytophthora ramorum* due to the extensiveness of the forests, the relatively high impact of the disease in this area, and the diversity of environments and disturbance histories.

Fig. 1 - High levels of mortality occur throughout Big Sur forests. There are still many host species alive but many are showing symptoms of being infected with *P.ramorum*.

Project Objectives

The objectives of this project are to:

Establish a network of long-term ecological monitoring plots across the Big Sur Ecoregion allowing us to:

- Evaluate the current distribution of *P. ramorum* in Big Sur.
- Understand the impacts of *P. ramorum*-associated mortality on the forest structure and community.
- Determine the structural, compositional and environmental variables that contribute to *P. ramorum* establishment or spread.
- Determine the relationship between changes in forest cover and recruitment due to *P. ramorum* and other conservation threats (e.g., invasive species, fire suppression).
- Better understand ecological drivers of the composition and dynamics of coastal forests.

Fig.2-(top) Example of Mixed-evergreen forest; (bottom) Redwood-tanoak forest.

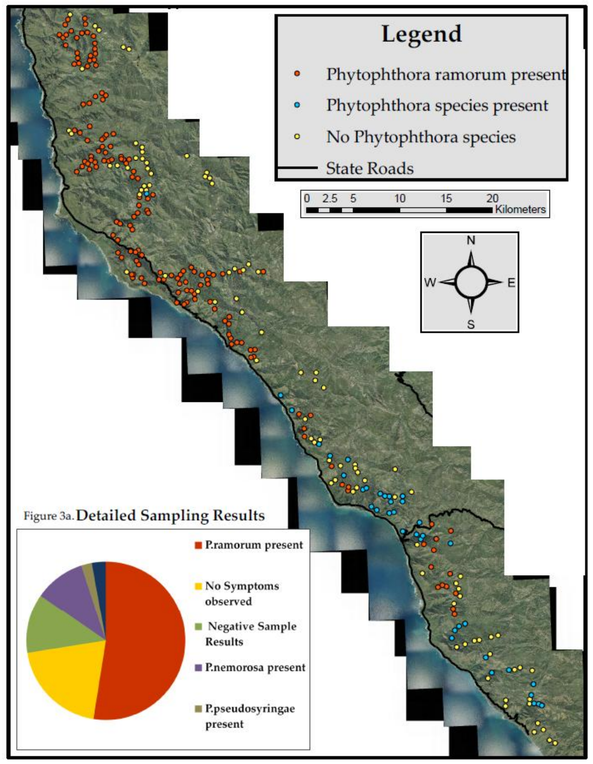

Fig. 3 & 3a - Map of all 280 plots established. 153 plots tested positive for *Phytophthora ramorum*, 37 are positive for other species of *Phytophthora* (see inset Figure 3a).

Study Design

High-resolution, digital aerial photography integrated into a GIS was used to map habitat types and tree mortality associated with *P. ramorum* in the Big Sur region. This information was the basis for a model built to randomly generate the location of the ecological monitoring plots. Plots were stratified by forest type, (Mixed-evergreen and Redwood-tanoak, Fig.2), level of tree mortality, fire history and land ownership (public versus private).

Within each circular, 1/20 ha (500 m^2) plot:

- All trees and shrubs with a dbh greater than one cm were measured. The length and width of all shrubs >1m^2 was measured.
- Species, diameter, height, crown position, health, and presence of diseases or pests were recorded.
- *Phytophthora* symptoms were noted and a subset of symptomatic plant tissue was collected and cultured to confirm presence of the pathogen. In some cases we conducted ELISA testing to further analyze samples.
- Percent cover of all tree, shrub and herbaceous species were recorded based on Braun-Blanquet cover classes.
- Number and species of all tree seedlings and seedlings >50cm were censused.
- Species and volume of coarse woody debris (logs on the ground >20cm diameter) were measured.
- Slope, aspect, elevation and geologic and geomorphic environment of the plot were recorded.
- A GPS location was recorded to conduct further GIS analysis with fire frequency, fire severity, land use history and climate.

Fig. 4 - Example of a healthy Mixed-evergreen forest in Big Sur.

- 280 SOD monitoring plots were established in '06 and '07 field seasons. We mapped and assessed over 13,400 trees.
- 143 plots on public land; 137 plots on private land; 163 Mixed-evergreen plots; 117 Redwood-tanoak plots, (Fig.2).

Results

- 153 of the 280 plots tested culture positive for *P. ramorum*, 37 different plots tested positive for other species of Phytophthora, (Fig.3); 56 had no symptomatic material to collect and 34 came back negative after laboratory tests (see inset Fig.3a).
- 20 plots had 100% infection of tanoak and a few plots had 100% infection of coast live oak.
- In *P. ramorum* positive plots, 72% of living tanoaks, 20% of coast live oaks and 16% of Shreve's oak were symptomatic (Fig. 5).

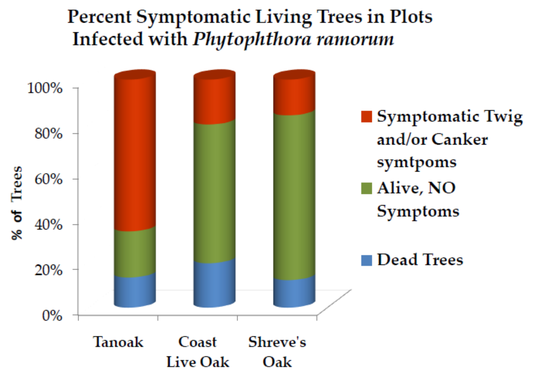

Fig. 5 – Percent of trees that were symptomatic, (having canker or twig symptoms) for tanoak, coast live oak and Shreve's oak in plots that were positive for *P. ramorum*. Number of tanoak, coast live oak and Shreve's oak trees in positive plots is 2527, 360 and 707, respectively.

- Mortality in positive plots was 13% for tanoak, 19% for coast live oak and 12% for Shreve's oak. However, much higher levels of mortality are occurring in certain stem size classes. For example, in tanoak, over 3 times the mortality is occurring in the larger size classes as compared to the smallest stem size class.
- Downed woody debris accumulation is higher in diseased plots. There are almost 3 times the amount of tanoak down woody debris and 1.4x's for coast live oak. This metric not only suggests mortality levels above the standing mortality measured, but also has implications for nutrient cycling and fire.

- With the loss of tanoak and oak there has been a shift in forest community composition favoring higher densities of non-lethal host species like bay (*Umbellularia californica*). There are significantly more bay stems in infected Mixed-evergreen plots than in uninfected Mixed-evergreen plots, (Figure 6).
- The loss of tanoak and oak species is further exemplified by the significant loss of live host basal area in infected Redwood-tanoak plots as compared to uninfected Redwood-tanoak plots. Host species are tanoak, coast live oak and Shreve's Oak, (Figure 7).

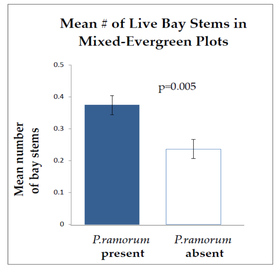

Figure 6.

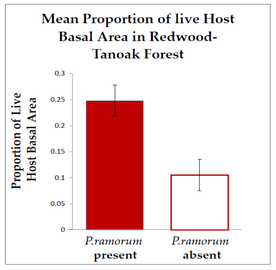

Figure 7.

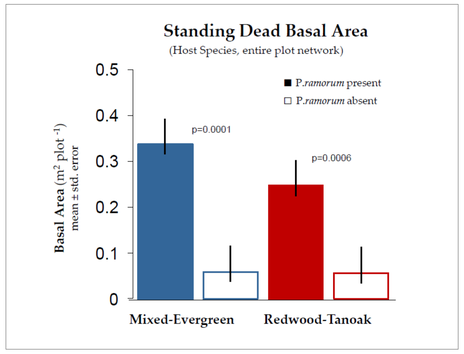

Figure 8. Mean standing dead stem basal area for host species is significantly higher in both forest types in infected plots compated to uninfected plots. For Redwood-tanoak plots host standing dead stem basal area was 4x's more in infected plots.

Fig. 9 - Example of high volumes of standing dead stems in an infected redwood-tanoak forest.

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