

**TITLE:** Determination of the incidence and impacts of *Phytophthora ramorum* in coastal forests of California

**LOCATION:** Coastal California

**DURATION:** Year 1 of 2-year project

**FUNDING SOURCE:** Fire EM

**PROJECT LEADER:**

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**PROJECT OBJECTIVES:** The overall objective of the proposed project is to determine the incidence and impact of *P. ramorum* on known hosts at a statewide scale in California. The main focus will be to determine mortality levels of the canker hosts: oaks and tanoak. Surveys of foliar hosts will also be included to gain an understanding of the overall incidence of the pathogen. The overall objectives will be accomplished by 1) Compiling *Phytophthora ramorum* plot data from multiple studies into a single meta-data set, 2) Examining the current plot network to determine if it is statistically representative of the geographical distribution of vegetation types and *P. ramorum* hosts in California, and 3) if necessary, establish an additional set of permanent plots in the second year to fill data gaps.

**JUSTIFICATION:** Sudden oak death (SOD), caused by *Phytophthora ramorum*, is an important emerging forest disease. The disease is significant from both biological and political perspectives. Biologically, it is clear that many thousands of oak and tanoak trees have been killed by the disease in California, raising concerns over fuels accumulation. In addition, laboratory analyses have confirmed the susceptibility of non-Californian oak species to infection (e.g., northern red oak). Because of these observations, national and international quarantines have been enacted to prevent movement of *P. ramorum* out of known infested areas of California and Oregon. However, the overall impact of the disease in terms of oak and tanoak mortality has not been quantified at large spatial scales in California. There are currently a number of monitoring projects funded by FHP associated with *P. ramorum* in coastal California and Oregon. Much of this monitoring has been aimed at early detection of newly established infections in areas where *P. ramorum* has previously been considered to be absent. These projects include aerial surveys, non-permanent random plots, and stream monitoring. FHM projects have also been tied to gaining baseline data on risk factors associated with the presence of *P. ramorum* and have established the coarse scale geographic distribution of *P.*

*ramorum* within California. FIA has also been involved in monitoring for *P. ramorum* to some extent (proposal funded in 2001). Our proposal aims to integrate a number of existing plot-based projects to examine the incidence of *P. ramorum* and its impacts at a statewide level. The project, although large in scope, is highly feasible, as much baseline data has already been collected and methodologies for expanding the plot network are in place.

## **DESCRIPTION:**

**a. Background:** The overall objective of the proposed project is to determine the incidence and impact of *P. ramorum* on known hosts at a statewide level in California. The main focus will be on determining mortality levels of the canker hosts, oaks and tanoak, due to *P. ramorum*. However, determination of mortality levels of oak and tanoak mortality due to other agents will also be examined. Surveys of foliar hosts will also be included to gain an understanding of the overall incidence of the pathogen. There are many potential difficulties in answering these questions. First is the inherent heterogeneity of vegetation types across the landscape in coastal California. Susceptible vegetation types (e.g., mixed-evergreen forest, redwood/tanoak forest) are often juxtaposed with non-susceptible vegetation types (e.g., grassland, chaparral) and urbanized areas on relatively small spatial scales. Second, the distribution of *P. ramorum* is also patchy across the landscape. This patchiness may be due to biological, environmental, or historical reasons (i.e., the pathogen's geographic range has not yet expanded to encompass the range of its hosts). Many field plots have been established in California to ask a number of questions concerning SOD disease ecology (e.g., what are the biological and environmental factors that predict the presence of SOD). Plot locations of most projects so far have been concentrated in areas of high disease severity and/or not evenly distributed across the infested region of the state to be able to confidently estimate impacts on oaks at the statewide scale. While some forests clearly have extensive overstory mortality, it is not known how much area is affected by SOD relative to the potential area that could be affected. The best approach to characterizing the statewide incidence and impact of *P. ramorum* would be to survey a large number of randomly located plots within the infested region characterized by different levels of oak abundance, foliar host abundance, and disease severity. It would be a large undertaking to establish a new network of plots with sufficient laboratory confirmation of the presence/absence of *P. ramorum* as well as more detailed information on the incidence of symptoms on canker and foliar hosts. Our approach will be to analyze existing data by integrating an already established plot network into a large meta-analysis. The combination of collaborators on this project has data available from 1082 plots established throughout coastal California. These existing data will be analyzed to determine the statistical validity of the meta-analysis for meeting our overall objective. If the plot network provides insufficient sampling to determine the impact of *P. ramorum* in a statistically valid manner, in year 2 we will establish additional plots to fill in data gaps in under-sampled forest types and/or geographic areas.

## **b. Methods:**

Objective 1. Data sets from plot-based studies at UC Davis, Sonoma State University and Phytosphere Research will be combined into a single database. The UC Davis group has established 480 plots (500 m<sup>2</sup> each) in coastal counties from Monterey County to Del Norte County. These are located in multiple forest types, with the majority in redwood/tanoak. The Sonoma State group has established 202 plots (225 m<sup>2</sup> each) randomly located over 275 km<sup>2</sup> in eastern Sonoma County. These plots are primarily in mixed evergreen, but include some plots

in redwood/tanoak forest. Phytosphere research has established 250 plots (200 m<sup>2</sup> each) in Sonoma County in several forest types. An additional, 150 200m<sup>2</sup> plots were established by slightly different methodologies in Marin, Sonoma and Napa counties. All plot locations will be entered into a GIS database. Plot variables (vegetation type, *P. ramorum* incidence, presence of mortality agents other than *P. ramorum*, etc.) will be recoded among the various projects for consistency and entered into a new database based in Microsoft Access. Presence or absence of *P. ramorum* has previously been confirmed via culturing on the majority of plots. Supplemental sampling of the plots will be done if needed. Many plots have been visited several times over the past 4 years. Plot location data is maintained for researchers on the website of the California Oak Mortality Task Force.

Objective 2. We will statistically test (chi square, binomial test) the hypothesis that the proportion of forest types sampled by these currently established plots is equal to the proportion of those forest types on the landscape. A vegetation database based on CALVEG and the California GAP Analysis Project has been previously established as part of a *P. ramorum* risk mapping project (Meentemeyer et al., Forest Ecology & Management, in press). Our plot data will be combined with the vegetation data to give a complete view of the relative sampling efficiency based on vegetation type in coastal California. In addition, the area affected by *P. ramorum* will be defined and we will test the relative sampling efficiency of locations to determine if certain areas on a statewide scale have been under-sampled.

Objective 3. Our goal is to have the number of plots in each forest type be proportional to the area that each forest type covers on the landscape. If under-sampling of various forest types and geographic areas has occurred, we will then establish an additional set of permanent plots that will fill in the data gaps. Plots will be randomly established in forest types on public lands based on results of initial analyses. Most efficient plot size will be determined from analyses. Both canker and foliar hosts will be sampled to confirm the presence of *P. ramorum*.

Objective 4. We will determine the incidence and impacts (i.e., mortality levels of oak and tanoak) in forest types and geographic areas with/without *Phytophthora ramorum* within coastal forests of California. This objective will be tested with the original data set to give a preliminary estimate of impact. If data gaps are found, impacts will be recalculated following survey of additional plots.

**c. Products:**

- a. Establishment of a database of long term monitoring plots in which the presence/absence of *P. ramorum* has been confirmed.
- b. Reports to FHM with results of the analyses and including maps of the affected areas.
- c. Peer-reviewed manuscripts quantifying the impact and incidence of *P. ramorum*.

**d. Schedule of Activities:**

Year 1: Winter 2004/2005. Compile meta-data set and analyze data.

Year 2: Winter 2005/2006. Establish and sample new plots for *P. ramorum*. Re-analyze data.

e. Progress/Accomplishments: N/A

**COSTS:**

	Item	Requested FHM EM Funding	Other-Source Funding	Source
<b>YEAR</b>				
<b>Administration</b>	Salary/benefits	\$54,625		
	Overhead	\$6934		
	Travel	\$2000		
<b>Procurement</b>	Contracting			
	Equipment			
	Supplies	\$2500		
<b>Total</b>		\$66,059		

Budget justification: Sonoma State University: \$46,225 for salary and benefits for ¾ time GIS technician; \$6934 for University overhead (15%); travel to regional meetings; supplies for computer including a dedicated hard-drive for this project. Phytosphere Research: \$8400 (\$70/hr for 120 hrs) to compile data into standard formats.

If the analyses suggest additional data is necessary, we anticipate a second year for the project in which plots will be established to fill in the data gaps. We anticipate a budget for this phase of approximately \$125,000.