

# Prevalence and Development of Disease on Coast Redwood Seedlings Caused by *Phytophthora ramorum*<sup>1</sup>

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## Abstract

Coast redwood (*Sequoia sempervirens*) is a host for *Phytophthora ramorum* but it is unclear if the pathogen represents a significant disease risk to this tree species. In an on-going field experiment, we are examining the prevalence of infection and the development of symptoms on coast redwood seedlings in naturally infested sites in southern Humboldt Co., California. In November 2006, healthy redwood seedlings were placed amid tanoak and bay trees naturally infected with *P. ramorum*. Disease incidence and symptom development are being observed monthly, and every two months, a subset of redwood seedlings is destructively sampled to investigate the location and extent of tissue colonization by *P. ramorum*. In order to correlate inoculum levels across field sites with disease development, rainwater is being collected and baited with rhododendron leaves to determine presence and frequency of positive *P. ramorum* rain traps. Results of this study will help evaluate the risk of *P. ramorum* to coast redwood seedlings and inform land managers of the potential for reforestation of infested sites with this species.

## Introduction

Coast redwood (*Sequoia sempervirens*) is a host for *Phytophthora ramorum* but it is unclear if the pathogen represents a significant disease risk to this species. *P. ramorum* was first isolated from saplings in Sonoma and Santa Cruz Counties, California in 2002 and Koch's Postulates were completed (Maloney and others 2002). Symptoms include needle lesions, cankers on small branches, and dieback of epicormic sprouts (Davidson and others 2003). Researchers also observed discoloration in sapling xylem up to 90 cm from stem inoculation (Maloney and others 2002). Detection from mature redwood tissue has been reported, but conclusive disease causality was not determined (Garbelotto and others 2003). In a comparison of artificial inoculation methods, whole plant dips led to symptoms most similar to those found in nature (Hansen and others 2005).

The objectives of this study were to evaluate the risk of disease to coast redwood seedlings caused by *P. ramorum*. To do this, we attempted to determine disease incidence in relation to time of year, weather and inoculum. We also wanted to examine disease development on redwood seedlings in association with a specific overstory species, California bay (*Umbellularia californica*).

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## Methods

### Experimental Sites

Experimental sites are located in southern Humboldt County, the site of the northernmost California SOD infestation (Table 1). Conditions in this area are potentially conducive for sporulation because of mild temperatures, heavy precipitation, and presence of hosts. Infestation around the Avenue of the Giants is unsettling due to the valuable ecosystem and the amount of human traffic in this area.

All sites are located along the Eel River on alluvial flats. The overstory is dominated by coast redwood. Symptomatic tanoak (*Lithocarpus densiflorus*) is present at all sites. California bay is present at two of the sites (Table 1).

Table 1—Location of experimental sites.

| Site           | Location                                         | Prevalence of disease symptoms on tanoak | Presence of California bay |
|----------------|--------------------------------------------------|------------------------------------------|----------------------------|
| O'Meara Grove  | Redway, CA<br>Humboldt Redwood State Park (HRSP) | High                                     | No                         |
| Tooby Park     | Garberville, CA<br>Garberville Community Park    | High                                     | Yes                        |
| Chandler Grove | 8 km north of Meyers Flat, CA<br>HRSP            | Low                                      | No                         |
| Chandler Grove | 8 km north of Meyers Flat, CA<br>HRSP            | Low                                      | Yes                        |

### Seasonality of Disease Incidence

Using a complete random design, 20 healthy, potted seedlings were placed at Tooby Park for a two-month period beginning in December, 2006. A new group of seedlings was placed at Tooby Park every two months through June, 2007.

Presence of *P. ramorum* was determined by isolation and PCR from selected stems, needles, and buds of each seedling. No seedlings were found positive for *P. ramorum* from any time period. Therefore, we were unable to determine when redwood seedlings are most susceptible to infection.

## Symptom Development

Thirty healthy seedlings were planted at each of the four research sites in December, 2006. Symptom development was monitored monthly through June, 2007. A count of necrotic needles, cankers and length of stem dieback per seedling was measured monthly. Growth of seedlings over time was used as an indicator of overall vigor.

No symptoms were detected on seedlings at any of the sites. Therefore, no relationship between symptom development and inoculum levels or presence of California bay could be determined.

## Detecting Inoculum

Rainwater was collected and attempts made to quantify inoculum (fig 1). Initially fifteen raintraps were established at each of the sites. The first method used, from December, 2006 through April, 2007, followed the protocol set forth by the Rizzo lab at UC Davis (Davidson and others 2005). Water was collected, and then filtered. The filter was placed onto pimaricin-ampicillin-rifampicin selective media (PAR), and the plates examined for colony forming units (CFU) at OSU.

Due to erratic detection, methodology was altered at the end of April. The second method followed a detection protocol similar to that used in Curry County, Oregon. Rhododendron leaf baits were placed in each of 60 raintraps, collected semi-monthly, and plated onto PAR to determine presence or absence of inoculum.

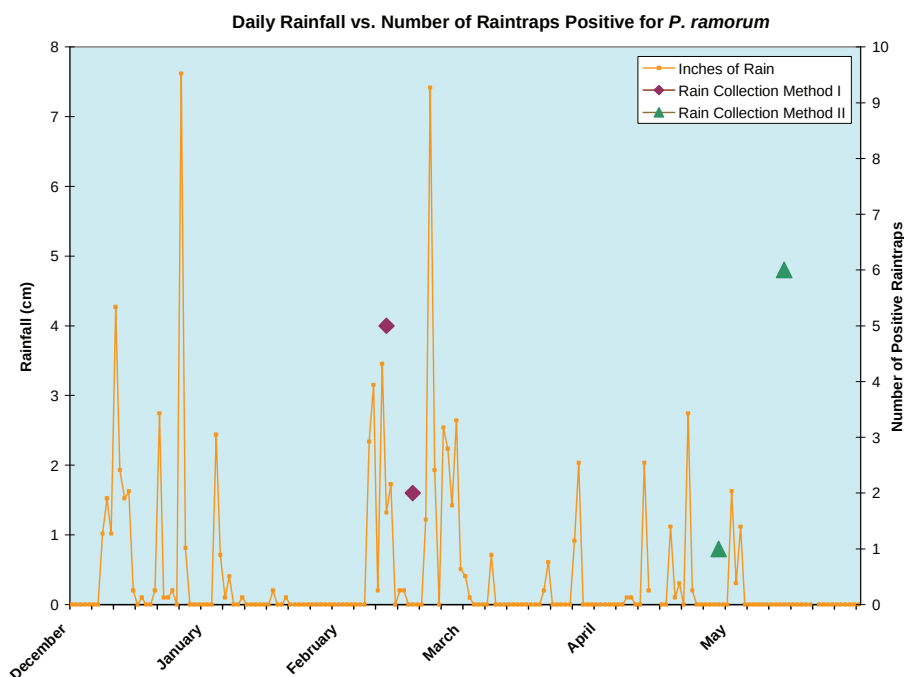


Figure 1-Rainfall was measured at the Eel River Conservation Camp in Redway, CA (approx. 8 km from the O'Meara Grove field site). Rain collection method I (◆) was discontinued at the end of April. Rain collection method II (▲) was begun at this time.

## Discussion

*P. ramorum* was rarely detected from rainwater in Humboldt County during the first half of 2007. In contrast, Curry County, Oregon had consistent detections from rainwater during this same period, but also received considerably more rainfall (179.7 cm vs. 76.5 cm). Lack of symptoms on redwood seedlings may be due to lower than average rainfall (76.5 cm from Dec.-May vs. 132.6 cm average). An additional season is necessary to assess the potential threat to coast redwood by *P. ramorum* in the field. In future studies on incidence and symptom development, a susceptible host, such as rhododendron seedlings, should be included as a positive control.

Controlled laboratory experiments are currently underway to determine the relationship between inoculum dose and disease incidence (or symptom development), examine distance of spread and tissues colonized within inoculated seedlings, and assess the level of sporulation on redwood seedlings.

## Acknowledgements

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## Literature Cited

**Davidson, J.M.; Wickland, A.C.; Patterson, H.A.; Falk, K.R.; Rizzo, D.M. 2005.**

Transmission of *Phytophthora ramorum* in mixed-evergreen forest in California. *Phytopathology*. 95: 587-596.

**Davidson, J.M.; Werres, S.; Garbelotto, M.; Hansen, E.M.; Rizzo, D.M. 2003.** Sudden oak death and associated diseases caused by *Phytophthora ramorum*. *Plant Health Progress*. Doi:10.1094/PHP-2003-0707-01-DG. (1 December 2005).

**Garbelotto, M.; Davidson, J.M.; Ivors, K.; Maloney, P.E.; Huberli, D.; Koike, S.T.; Rizzo, D.M. 2003.** Non-oak native plants are main hosts for sudden oak death pathogen in California. *California Agriculture*. 57: 18-23.

**Hansen, E.M.; Parke, J.L.; Sutton, W. 2005.** Susceptibility of Oregon forest trees and shrubs to *Phytophthora ramorum*: a comparison of artificial inoculation and natural infection. *Plant Disease*. 89: 63-70.

**Maloney, P.E.; Rizzo, D.M.; Koike, S.T.; Harnik, T.Y.; Garbelotto, M. 2002.** First report of *Phytophthora ramorum* on coast redwood in California. APS online. [www.apsnet.org/online/SOD/Papers/APS/PDnote\\_86-11a.html.0020](http://www.apsnet.org/online/SOD/Papers/APS/PDnote_86-11a.html.0020). (1 April 2006).