A Case Study to Evaluate Ground-Based, Wildland Survey Methods for *Phytophthora ramorum* in Coast Live Oak Stands in California[1]

Susan J. Frankel[2], Sylvia Mori[3], Janice Alexander[4], Don Owen[5], Jennifer Davidson[3], and David M. Rizzo[6]

Abstract

In a case study, we evaluated observers' accuracy in detecting *Phytophthora ramorum* and their ability to estimate percentage of infested area in coast live oak (*Quercus agrifolia*) stands in California. The study compared visual detection of symptoms on California bay laurel (*Umbellularia californica*) and oaks with results from three permanent 1-hectare plots. Each plot had 100 percent survey of all stems and varied in infection level (Sonoma County - 84 percent infection; Napa County - 68 percent infection; and Marin County - four percent infection). In 50 randomly selected plots at each site, an expert and novice observer noted the presence or absence of *P. ramorum*. These observations were used to test the following null hypotheses: (1) expert and novice observers have the same detection ability; and (2) expert and novice observers can accurately detect symptoms. The overall analysis shows the experts' assessments of infection level were closer to true than the novices' assessments. The observers tended to over-estimate the amount of infection by larger amounts when less disease was present. The novice assessment was 23 percent higher for the plot with four percent infection. The expert assessments were within the 95 percent confidence interval of the estimated proportion, indicating that a trained observer can accurately detect symptoms of *P. ramorum* in coast live oak stands in California.

Key words: Phytophthora ramorum, survey methods

---

[1] An abstract of a poster presented at the Sudden Oak Death Second Science Symposium: The State of Our Knowledge, January 18 to 21, 2005, Monterey, California.

[2] USDA Forest Service, Pacific Southwest Region, Vallejo, California: sfrankel@fs.fed.us
[3] USDA Forest Service, Pacific Southwest Research Station, Albany, California
[4] University of California, Cooperative Extension, Marin County, California
[5] California Department of Forestry and Fire Protection, Redding, California
[6] Department of Plant Pathology, University of California, Davis, California

Introduction and Objectives

This study evaluates the precision and accuracy of wildland surveyors at estimating infection by *Phytophthora ramorum*. We re-measured three permanent 1-hectare plots in coast live oak forests where infection levels of *P. ramorum* had previously been determined by Jennifer Davidson (Fairfield Osborn Preserve, Skyline Park, and Pacheco Open Space). In addition, we compared accuracy for detecting *P. ramorum* symptoms between two surveyor teams, one expert and one novice.

Methods

Sampling design

The plot attribute to be estimated was proportion of *P. ramorum* hosts with disease symptoms. We decided that a desirable level of observer accuracy would be within +/- 10 percent of the true proportion and we chose a sampling design to achieve this level of accuracy with a precision of 90 or 95 percent confidence. We split the 1-hectare plots into 100 subplots of 10 x 10 meters for ease of sampling. Prior to sampling, we determined the minimum sample size required for a 10 percent margin of error (|True proportion - estimated proportion|= 0.1) with a 95 percent confidence. We evaluated the minimum sample size needed using Lenth's sample size calculation by comparing field survey results to the model. (For more calculations use: http://www.stat.uiowa.edu/~rlenth/Power/). This calculation was done assuming the greatest variance possible, a proportion of 0.5 - the worst-case scenario. In our example, assuming the plot had 50 percent infection level we would survey 50 0.01-hectare subplots for presence or absence of *P. ramorum* (*fig. 1*).

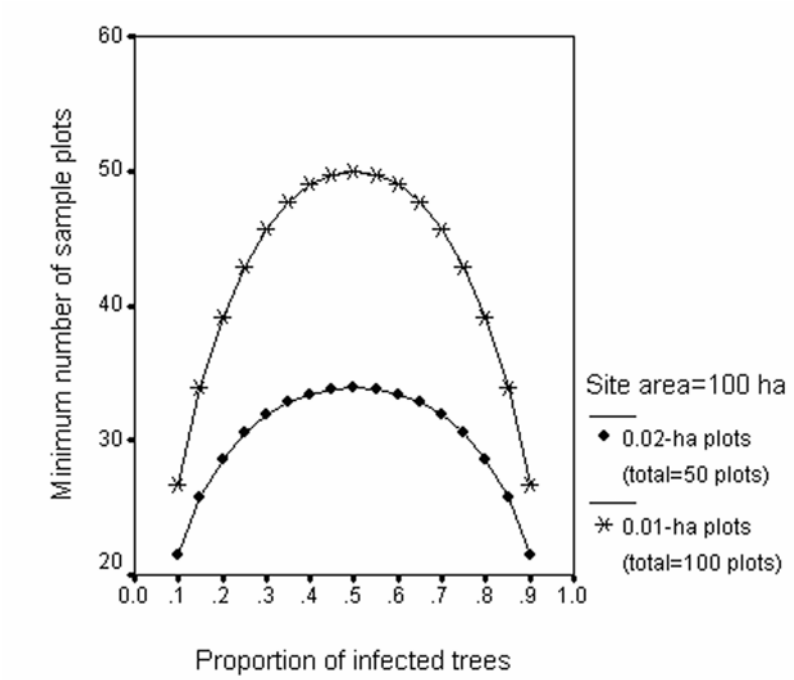

Figure 1 —Minimum number of sample subplots within a one hectare block.

Data collection and lab analysis

In October 2003, we assembled two survey teams and visited the three oak woodland sites. We defined the novice team as having only an introductory training in symptom recognition, while the expert team had many years experience in field forest pathology. Neither team knew the true proportion of infection in any of the three plots prior to sampling. For each site, 50 0.01-hectare subplots were chosen at random within the 1-hectare plot. Each team visited the 50 subplots and noted presence or absence of the pathogen based on visible symptoms. When no host plants were present in a subplot, another subplot was chosen, at random, as a replacement. For each subplot, each team also collected samples to be analyzed for confirmation of *P. ramorum* symptoms. Lab samples were collected, labeled, and shipped the same day following the standard California Department of Food and Agriculture (CDFA) protocol using PDR slips, and sent to Cheryl Blomquist, CDFA in Sacramento.

Data analysis

Permanent plot data from Davidson provided the true proportion values (mean infection level) for comparison with survey team results. These data represented 100 percent samples, and therefore, were considered accurate of the true infection levels. Results were analyzed by presence or absence of *P. ramorum* in the 50 randomly selected subplots at each site. The following results compare the expert and novice team results against the true results for each plot and the amount of agreement

between the two teams. The data were analyzed with SAS (v.9.1.3) GENMOD procedure.

Results and Discussion

Fairfield Osborn Preserve had the highest infection level (84.1 percent) followed by Skyline (68.2 percent), with the Pacheco site showing almost no infection (four percent). The expert team's assessment of infection level was closer to true than the novice team's assessment, though both teams tended to estimate higher levels of infection when the true infection level was very low. However, due to the lack of replications, it is not possible to make statistically valid inferences about the interaction level of experience and level of *P. ramorum* infection. We can only conclude that the true proportions were within the 95 percent confidence interval of the expected mean for FOP and Skyline, but not for Pacheco *(table 1 and fig. 2*), and that the expert team was significantly more accurate than the Novice team (p=0.083).

Table 1 – *Estimated proportions compared to the true proportions using initial true information and corrected true information (new P. ramorum infection.*

		True % of *P.r.*	Estimated% of *P.r.*	Lower 95% bound	Upper 95% bound	True % of *P.r.* within 95% CI?
FOP	Expert	84.1	86.4	76.3	92.6	Yes
FOP	Novice	84.1	91.4	83.5	95.7	Yes
Pach	Expert	4.0	9.5	4.9	17.7	No
Pach	Novice	4.0	15.0	8.4	25.4	No
Sky	Expert	68.2	68.4	55.8	78.8	Yes
Sky	Novice	68.2	78.4	66.9	86.7	Yes

Laboratory results confirmed that trained observers can use visual symptoms in Coastal Evergreen Forests (mix of coast live oak, California bay laurel, and so forth) to estimate the level of *P. ramorum* infestation in a stand. A lesser-trained observer may not be as accurate as a professional, but estimates of disease were still within acceptable levels, with the caveat that proportions will likely be over-estimated by any observer. We cannot say what additional amount of training would be necessary to move a novice to the expert level, but the novice level of accuracy may be acceptable depending on the survey objectives.

Because surveys may be more likely in areas of low disease occurrence - as with early detection efforts - actual disease proportion may be much lower than any estimated proportion, even with well-trained surveyors. Also, we found that the amount of time and difficulty of the survey increases greatly in areas where the

pathogen is not present or present at low levels (less than approximately 25 percent). Due to leaf drop on bay and new symptom expression, the time lag between establishment of the true disease proportion on the permanent plots and our survey may have introduced some error. In fact, there were three cases at the Skyline site where the lab analysis confirmed *P. ramorum* in areas not noted by the initial permanent plot data.

This is a case study without replication, not a generic recipe for survey methodology. Each survey needs to be designed to meet specific objectives, terrain, and vegetation. For example, transects may be more efficient than plots when actually surveying a site for *P. ramorum*. Also, results of our study, as in any other, are dependant on the size of the sampling area. A smaller subplot size could have greatly changed our estimates of infection at any of the three sites we visited.

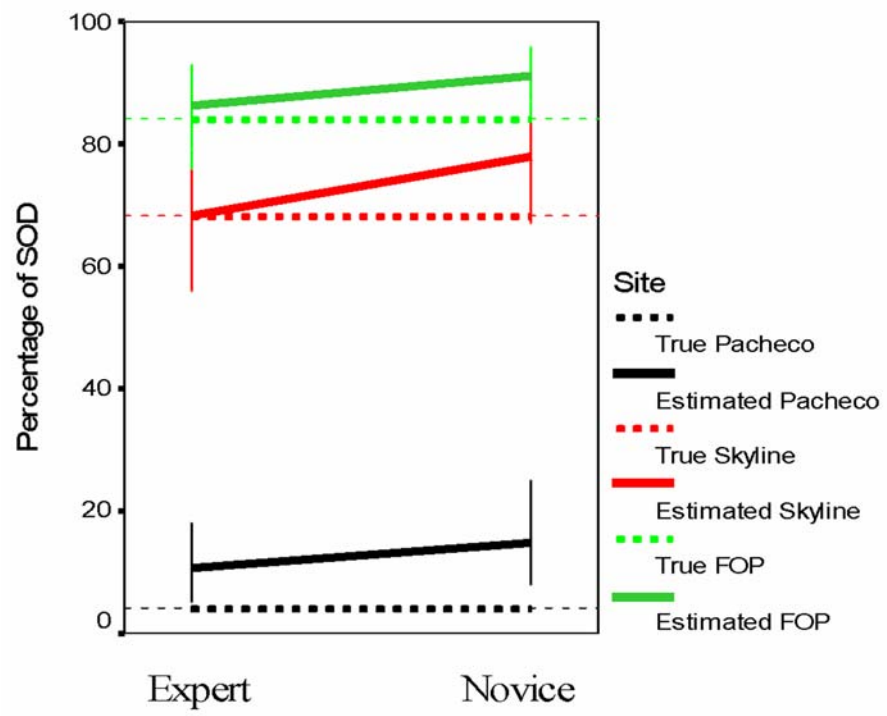

Figure 2 —Estimated levels of infection and 95 percent confidence interval for expert and novice compared to the true levels at the different sites.

Summary Conclusions

- Sample size based on 50 percent disease incidence was adequate for accurately determining the infection rate at three sites with varying infection levels.
- Laboratory results confirmed that visual symptoms can be used in Coastal

Evergreen Forests to estimate the level of *P. ramorum* infestation in a stand.

- Experts are better than novices, though both surveyors overestimated when infection level was low.

References

Lenth, R.V. 2001. **Some practical guidelines for effective sample size determination.** The American Statistician 55: 187-193.