Understanding the Disposal and Utilization Options for *Phytophthora ramorum* Infested Wood[1]

John Shelly[2], Ramnik Singh[2], Christine Langford,[2] and Tad Mason[3]

Key words: Phytophthora ramorum, sudden oak death, wood properties, firewood, biomass, salvage lumber, disease monitoring

Abstract

Removing trees inflicted with the sudden oak death (SOD) disease is often necessary because of hazard issues or homeowner/landowner desires. An alternative to disposal of this material is to find acceptable uses for this diseased material. A series of studies is being conducted to help understand the risk of spreading the *Phytophthora ramorum* infested wood through disposal and utilization activities. Two collection yards were set up in California for wood suspected of being infected with *P. ramorum*, one in Marin County and one in Santa Cruz County. More than 1,155 tons of woody, *P. ramorum* host material has been processed through the collection yards since May 2003, most from the removal of hazard trees. This material was converted into fuel for biomass power plants, firewood, and lumber. In addition to operating the collection yards, this project included periodic monitoring for *P. ramorum* spores during various stages of the processing and transportation by sampling the delivered host material and monitoring the host vegetation growing in and around the collection yards.

The periodic sampling of woody materials transported to and processed in the collection yards yielded a small number of positive cultures of *P. ramorum* isolated from a variety of the unprocessed and processed materials. Of the 418 samples collected, the following tested positive: two of 84 chip samples, two of eight California bay laurel leaf samples, eight of 145 samples of freshly split firewood, one of 85 samples of firewood air dried for about 6 months, nine of 93 grinder and saw dust samples, and one of three rainwater runoff samples. Furthermore, the sampling results of the host vegetation growing in and around the collection

[1]A version of this paper was presented at the Sudden Oak Death Second Science Symposium: The State of Our Knowledge, January 18-21, 2005, Monterey, California. This project is in part co-funded by the USDA Forest Service, Region 5 State and Private Forestry and the California Department of Forestry and Fire Protection (CDF), under CDF Agreement # 8-CA-01257.

[2] University of California Cooperative Extension Advisor, John.shelly@nature.berkeley.edu; Post Graduate Researcher, rsingh@nature.berkeley.edu; Staff Research Associate, chrintine.Langford@nature.berkeley.edu; University of California Richmond Field Station, Richmond, CA 94804.

[3] Forester, tmason@tssconsultants.com; TSS Consultants, Rancho Cordova, CA

yards confirmed the presence of *P. ramorum* at each site before operations began but continued sampling has not revealed any significant infestation increase.

This early data suggests that alternatives to disposal exist for *P. ramorum*-infested wood. Furthermore, although *P. ramorum* can be isolated from various stages of processing at the collection yards, no evidence has been gathered to support the hypothesis that the collection, sorting, and processing activities in the collection yards increases levels of *P. ramorum* infestation in and around the sites.

Introduction

This project was initiated in response to concerns raised by the California Oak Mortality Task Force (COMTF) that disposing or using *P. ramorum* infested woody materials would spread this pathogen that is potentially lethal for many hardwood trees across the country. The potential to spread plant pathogens by moving infected plants and plant materials from one location to another is well documented in the literature (Erwin and Ribeiro 1996; Garbelotto 2003; Davidson and others 2002). The list of host plants for *P. ramorum* continues to grow with the possibility that many of the important tree species of California's forests could become hosts (Garbelotto and others 2003). Unlike most other *Phytophthora* species, *P. ramorum* cankers are found highly associated with the bark of host trees (Storer and others 2001). Also, two beetles of the Scolytidae family, the western oak bark beetle (*Pseudopityophthorous pubipennis*) and the oak ambrosia beetle (*Monarthrum* sp.) are also known to be highly associated with this disease in infected trees (Storer and others 2001). However, the role these beetles play in the spread of the pathogen is not well understood since the high incidence of attack appears to coincide with the latter stages of the disease (Furniss and Carolin 1977). Although it is considered unlikely that the beetles play a significant role in pathogen spread they could be a valuable tool for measuring *P. ramorum* activity in a region.

Based on an initial list of host plants and the realization that suitable hosts could be found throughout the country, public agencies were quick to regulate the transport of infested material and implement quarantine zones. The California Department of Food and Agriculture established intrastate regulations in 2001 (Anon. 2005) followed by the enactment of federal interstate regulations by the U.S. Department of Agriculture Animal and Plant Health Inspection Service (Anon. 2002). Both sets of regulations were enacted before studies of *P. ramorum* infested wood could be completed. Recognizing that the likely pathways for the spread of *P. ramorum* are by water, soil, infested plant materials, and perhaps by air, the regulations encourage that infested material be quarantined and left in place if possible. However, it is not

always possible to leave infested material at the site of the infestation. Many *P. ramorum* infested trees are in urban areas, public areas, or adjacent to roads or utility lines. Such trees are often considered hazard trees and they must be removed. The removal of large numbers of these trees results in high, unbudgeted expenditures and often a disposal problem. As a woody material, this biomass could generate some value as consumer products but it was unclear if utilization activities can contribute to the spread of the pathogen. Under current regulations, if host plants and plant materials including wood and unprocessed wood products are transported outside of a regulated county they become subject to intensive inspection and permitting. Based on the premise that *P. ramorum* in trees thrives only on leaves or directly beneath the bark, wood and wood products can be exempt from the regulations as long as they are free of bark. However, the actual risk of spreading the pathogen by moving wood and wood products, with or without bark, was not well understood.

The goals of the project reported in this paper were to study the risks of moving material infested with *P. ramorum* from the site of its initial infection to a central location or processing facility and to identify potential uses for the infested material. The approach used to gauge the risk was to track the infestation levels of *P. ramorum* and bark beetles in and around collection yards during the life of this project. Two collection yards for *P. ramorum* infested wood were set up and actively managed under this project. The Marin County collection yard, located at Marin Resource and Recovery in San Rafael, California, opened in May 2003 and operated for 20 months at the time this paper was written. The Santa Cruz County yard, located at the Santa Cruz County transfer station in Ben Lomond, California, was opened in December 2003 and operated for 13 months. Both yards are scheduled to close by July 2005.

Objectives

The overall objectives of the project included:

- Design a comprehensive disposal and utilization plan for Marin and Santa Cruz Counties that incorporates the views of public agencies and private enterprise.
- Develop protocols for the removal and transportation of *P. ramorum* infested woody material and for monitoring the potential pathogen spread
- Evaluate the relationship between transporting and processing *P. ramorum* infested wood and the risk of spreading the pathogen

- Evaluate the basic wood properties of *P. ramorum* infested wood and the value-added utilization potential and implement the distribution of *P. ramorum* infested wood to appropriate markets.

Methods

To create a disposal and utilization plan that addressed the objectives of the project, a series of meetings was conducted with representatives of interested organizations and stakeholders. These included state and county agencies responsible for the removal and disposal of woody biomass as well as tree service companies, arborists, land managers, and commercial users of woody biomass. An outcome of these meetings was the establishment of two collection yards to serve as a central location for the drop-off of host trees suspected of having SOD.

Consultations with state regulators and other researchers studying SOD led to a set of protocols used in this project to define the rules of participation in the project and the methods used to monitor the activities. Only host material suspected of being infected with *P. ramorum* and identified by a person having received training in *P. ramorum* symptoms was accepted at the collection yards. This material had to be removed and transported to the collection yard by a tree service company or other qualified expert following the transportation guidelines distributed to all potential participants and also posted on the project internet web site (http://groups.ucanr.org/sodbusters). Once at the yard, the *P. ramorum* infested material temporarily stored at the site was physically separated from other woody biomass operations. This material was stored until enough volume was collected to justify moving it to a utilization market. During this sequence of events the material, the site, surrounding environment, and processing activities were monitored for the presence of *P. ramorum* and bark beetle activity according to the protocols described in an earlier progress report (Shelly and others 2004).

In summary, the following monitoring was conducted according to the schedule outlined in *table 1*.

- Determined base line levels of infestation in the area surrounding the collection yard by inspecting all of the following host plants found in circular plots (6 m radius) spaced 20 meters apart along transects emanating from the collection yard.
    - Coast live oak (*Quercus agrifolia*) – inspected for SOD symptoms

  - California bay laurel (*Umbellularia californica*) – collected symptomatic leaves from trees taller than 2 meters that were used for laboratory examination (see culture techniques below)
- Monitored beetle levels by capturing insects in ethanol-baited, "Lindgren" beetle traps and periodically counting the catch of scolytids.
- Periodically sampled collection yard materials
  - Delivered *P. ramorum* infested woody biomass (chips, branches, leaves, and logs)
  - *P. ramorum* susceptible rhododendron plants (*Rhododendron var. Colonel Coen*), potted and placed in the collection yard (sentinel rhododendrons)
  - Airborne dust generated during unloading of *P. ramorum* infested material from trucks (only at the Marin County yard and the Soledad biomass power plant)
  - Rain water runoff from chip piles (only at the Marin County yard)
- Periodically sampled materials during processing activities
  - Airborne dust generated during wood grinding operations
  - Small wood particles that fall from the grinders (grinder fines)
  - Firewood with bark as it was processed
  - Sawdust from sawmill as logs were processed into lumber
- Periodically sampled processed firewood as it dried

Table 1 – *Schedule of sampling at each collection yard (M = Marin county collection yard, SC = Santa Cruz County collection yard, SM = sawmill site in Davenport, S = Soledad biomass power plant).*

Item Sampled	Every 2 weeks	Every Month	Every 2 months	Every 6 months	As needed
Host plants in sample plots				M,SC, SM	
Sentinel rhododendrons			M, SC	SM, S	
Beetles		M, SC	SM		
Rain water runoff from collection yard					M
Delivered chip material and CA bay laurel leaves					M, SC
Delivered sawlogs					SC
Airborne dust generated during delivery	M				S
Grinder fines and sawdust					M, SC, SM
Lumber					SM
Freshly split Firewood					M, SC, SM
Stored firewood				M, SM	

Culture techniques

All chip, wood particle, dust, water and solid wood samples were subjected to a pear baiting technique to determine the presence of *P. ramorum*. Hard, green d'Anjou pears without wounds or bruises were partially submerged for 3 days at 20 °C in deionized water containing the material being tested. The pears were then removed from the water and air dried at 20 °C for 2-5 days. Any characteristic *Phytophthora* lesions that appear on the pears were isolated and placed on an agar growth medium prepared with ampicillin, rifampicin, and pimaricin (PARP) using sterile techniques. Organisms that grew on the PARP plate were examined for *P. ramorum* characteristics to determine the presence of the pathogen (Blomquist and Kubisiak 2003). Leaves collected from host plants were not pear baited, the *Phytophthora* lesions on the leaves were directly plated on to PARP.

The Plant Pest Diagnostics Center, California Department of Food and Agriculture (CDFA) in Sacramento performed DNA analysis using polymerase chain reaction (PCR) techniques to confirm the presence of *P. ramorum* on all plates that grew organisms with *P. ramorum* characteristics.

Utilization analysis

Data gathered on the properties of the infested wood collected in the study area included tree size and form, gross wood characteristics, wood moisture content at the time of the diseased wood delivery, and wood density. Moisture content was measured on solid wood specimens taken from the processed firewood and logs selected for lumber processing. The same specimens were also used to measure the density. These properties were used to determine the level of degradation in the wood and to identify the best use for the material. Products considered included biomass powerplant fuel, firewood, and lumber.

Results

A total of 1,155 tons of potentially *P. ramorum* infested wood was delivered and processed at the two collection yards (*table 2*). In the 20-month period from May 2003 to December 2004, the Marin County collection yard received 856 tons from 14 private tree service companies and three public works departments. The Santa Cruz County collection yard received 299 tons in the 12-month period from December 2003 to December 2004, all as hazard tree removals under contact of the County of Santa Cruz during the 6-month period from December 2003 to June 2004. At the Marin County yard the deliveries were tracked by species. Of the 929 trees removed and delivered to the yard, 761 (82 percent) were tanoak (*Lithocarpus densiflorus*), 160 (17 percent) were coast live oak (*Quercus agrifolia*), five (0.5 percent) were California black oak (*Quercus kelloggi*), and three (0.3 percent) were California bay laurel (*Umbellularia californica*). Although the deliveries could not be tracked by species at the Santa Cruz County yard, the species breakdown is assumed to be similar based on the inventory of hazard trees by the county in which tanoak made up about 75 percent of the material and coast live oak 21 percent.

Table 2 – *Breakdown of the SOD-diseased material delivered to the Marin County collection yard and the Santa Cruz County collection yard.*

Tree Species	Marin (19 months)		Santa Cruz (12 months)	
	# of Trees	Tons	# of Trees	Tons
Lithocarpus densiflorus (tanoak)	761	na	na	na
			na	na
Quercus agrifolia (coast live oak)	160	na	na	na
Quercus kelloggi (California black oak)	5	na	na	na
Umbellularia californica (California bay laurel)	3	na	na	na
Total	929	856		299
Average deliveries/active month		45		46

Of the total 1,155 green tons of material collected, about 84 percent were processed into biomass powerplant fuel, 14 percent converted into firewood, and 2 percent processed into lumber. The commercial biomass power plants that received the biomass fuel from this project were in Rocklin, Woodland, and Soledad, California. All of the biomass fuel chips processed at the Santa Cruz County yard were sent to the Soledad facility, a total of 283.4 green tons. The Marin County yard processed 649.5 tons of biomass fuel chips that were distributed to all three of the powerplants listed above.

Monitoring for changes in P. ramorum *infestation*

Host vegetation

A baseline of *P. ramorum* infestation was established before each collection yard began operations by sampling the host vegetation in and around each collection yard. The same trees were reexamined every 6 months throughout the duration of the project to determine changes in the level of the disease. The baseline survey of *P. ramorum* infestation at the Marin County site in the spring of 2003 showed that 69 percent of the bay laurel trees in all plots were infected with *P. ramorum*. This overall infestation level decreased to 61 percent in the spring of 2004 after 1 year of SOD-diseased wood collection activities. This was due to a few trees that exhibited *P. ramorum* symptoms initially but were no longer symptomatic in subsequent sampling. This may not actually indicate a real drop in infestation but it could be a reflection of the natural variation of the symptoms. Although the rate of infestation appeared to be greater closest to the collection yard (*figure 1*), this is believed to not be influenced by the collection yard activities. The collection yard is located at the base of a steep slope and all of the plots closest to the collection yard are at the base of the slope. The higher percentages of infected trees at 450 feet from the collection yard were likely a reflection of higher natural *P. ramorum* infestations expected at the bottom of a steep slope. The observed lower infestation rates in the fall were a reflection of the difficulty in sampling infected bay laurel leaves in the fall when most of the infected leaves have fallen from the tree.

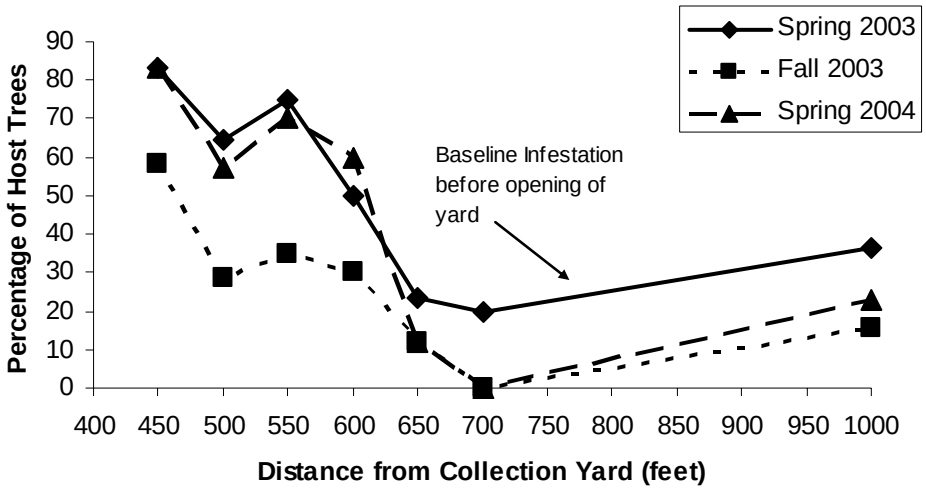

Figure 1 – Percentage of host trees in each sample plot at the Marin County collection yard that are infected with *P. ramorum*.

Similarly, no changes were observed with the coast live oak trees in the sample plots that could be explained by the collection yard activities. The overall level of symptomatic coast live oak trees in all transects remained constant, but one additional coast live oak developed symptoms in a control plot far from the collection yard activities and one of the symptomatic trees in a plot close to the collection yard became symptom free.

None of the sentinel rhododendron plants placed in the collection yard developed positive *P. ramorum* cultures. Similar results were found at the Santa Cruz County collection yard where the slight changes observed in the infestation were seasonal and also located in plots far from the collection yard activities.

Beetle activity

Bark beetle activity in and around the two collection yards is summarized in *figure 2*. The beetles were most active in both yards in the spring/early summer months with a secondary period of activity in the fall. This is consistent with the expected life cycle of bark beetles. During late May to early June 2004 the beetle count in the trap inside the Marin County yard reached a peak of 2,352 beetles. This dramatic increase in bark beetle activity coincided with numerous deliveries of *P. ramorum* infested hazard trees. A similar peak also occurred at the same time in the Santa Cruz County yard; this peak was also associated with numerous deliveries of *P. ramorum* infested hazard trees. The beetle counts in the control D and E baited traps, which were

located the furthest from the collection yard, were generally quite a bit less than the counts inside the collection yards with the exception of the August 2003 peak for control two at the Marin County site. This control two count was in the plot farthest from the collection yard in an area with many dead and dying coast live oak trees and is believed to be a reflection of normal beetle activity and not related to the collection yard activities. With the exception of the traps adjacent to the collection yards that may be influenced by the collection yard activities, the other traps showed a good record of the background beetle activity in the area.

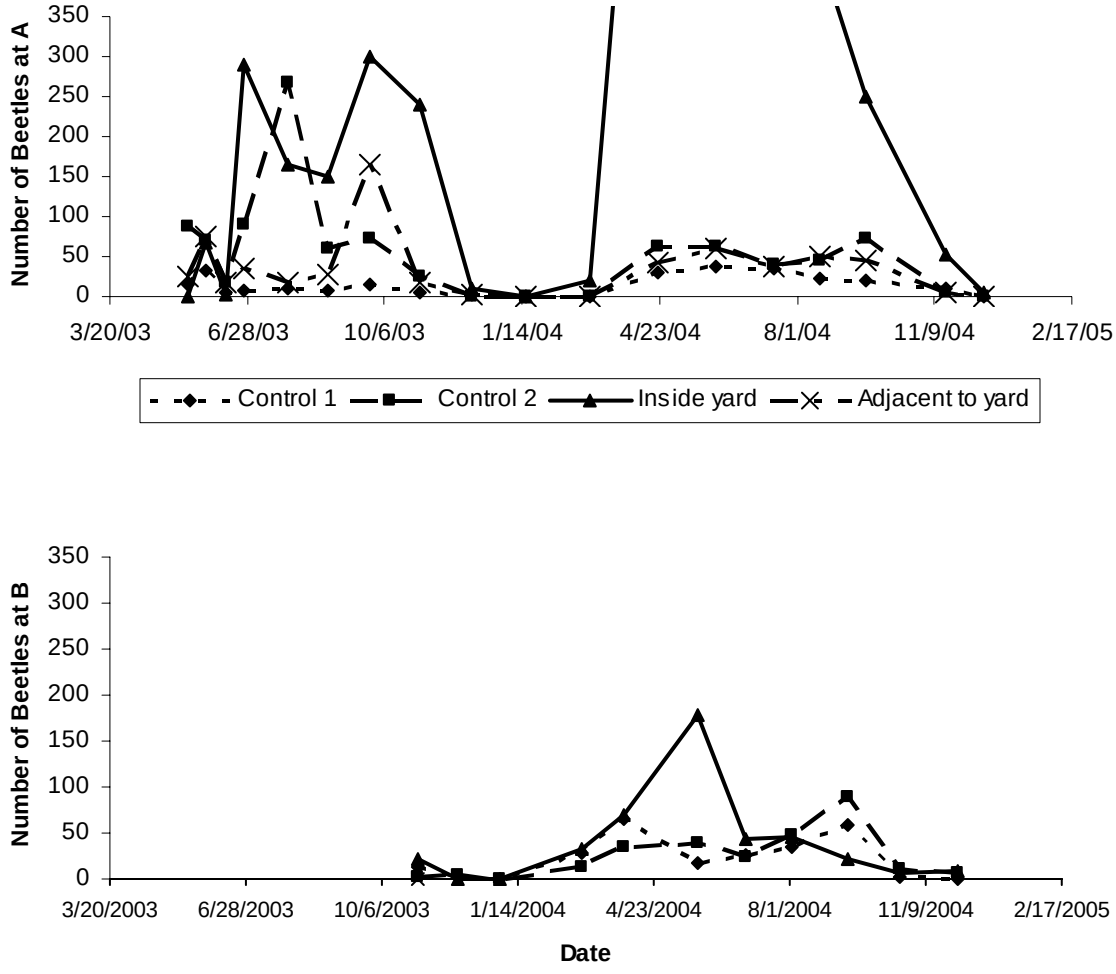

Figure 2 – Scolytid activity at the collection yards (A is Marin County, B is Santa Cruz County).

Monitoring of delivered materials

The results of the monitoring activities for *P. ramorum* in the host material delivered to and processed at both collection yards are presented in *table 3*. To date, *P. ramorum* has been cultured from the following specimens:

- two of eight bay leaf samples recovered from the chips bin in the collection yard
- two of 84 samples of chips from the collection bins
- eight of 145 pieces of freshly split firewood
- one of 85 pieces of firewood dried for about 6 months
- nine of 93 specimens of grinder and saw dust collected next to the wood grinders and sawmill
- one of three samples of rainwater runoff from chip piles

None of the samples from air-borne dust in the collection yards, near the processing equipment, or the sentinel rhododendron plants have tested positive for *P. ramorum*.

Table 3–*P. ramorum monitoring of P. ramorum infested material delivered or processed at both collection yards.*

Sample	Marin C. Yard		Santa Cruz C. Yard		Sawmill		Powerplant	
	# tested	*P. ramorum* positive	# tested	*P. ramorum* positive	# tested	*P. ramorum* positive	# tested	*P. ramorum* positive
Chips	63	1 (1%)	21	1 (1%)				
Grinder fines	12	0 (0%)						
Fresh firewood	100	8 (8%)			45	0 (0%)		
Air-dried firewood	85	1 (1%)						
Air-borne dust	125	0 (0%)			6	0 (0%)	12	0 (0%)
Grinder/saw dust	41	8 (20%)	11	1 (9%)	41	0 (0%)		
Sentinel rhododendrons	14	0 (0%)	4	0 (0%)	2	0 (0%)		0 (0%)
Bay laurel leaves	8	2 (25%)						
Rainwater	3	1 (33%)						

Wood properties and lumber quality

Twenty-four logs (15.5 tons total weight) of *P. ramorum* infested logs were selected for sawlog potential at the collection yard and delivered to the sawmill in Davenport, CA. The species mix of the sawlog test was 21 tanoak, two coast live oak, and one California black oak. The yield and physical properties of the logs and lumber produced is summarized below in *table 4*. The average moisture content of the heartwood and softwood lumber was 84 percent and 74 percent respectively. The specific gravity (oven dry mass/green volume) of the tanoak processed was 0.57.

The logs were processed into 8-foot long lumber measuring 5/4-inch thick and various widths of 3-inch, 4-inch, and 6-1/4". All of the solid wood residue from the sawmilling operation was processed into firewood and the sawdust was collected and stored on site for future analysis and potential utilization. The total log volume of 412.84 ft^3 (4,954 board feet (bf)) produced 188.89 ft^3 (2393 bf) of green, 5/4-inch thick lumber or a lumber yield of 47.8 percent. The remaining 52.2 percent of the log volume not converted into lumber was either sawdust or a solid wood residue that was converted to firewood.

Table 4 – *Green lumber yield and wood properties of test sawlogs by species and log quality.*

Species	Log Quality	Number of logs	Avg. MC (%)	Avg. SG	Avg. Diameter (in)	Green Lumber Vol. per log (bf)	Yield (%)
Tanoak	Good	9	92.1	0.55	19.5	103.1	47.0
Tanoak	Moderate	8	81.2	0.60	17.7	87.9	50.5
Tanoak	Low	3	76.0	0.60	21.9	113.4	45.2
Coast live oak	Good	3	75.3	0.70	20.8	102.8	43.7
CA black oak	Good	1	90.6	0.56	17.9	98.0	56.5
Overall Average		24	84.8	0.57	19.3	99.7	47.8

The logs were evaluated for quality on the basis of log form (straightness and taper), presence and level of decay, level of beetle infestation, and the presence of heart stain (known to be highly correlated with drying defects). The lumber yield varied from 45.2 percent to 50.5 percent but this variation was not correlated with log quality, the moderate category resulted in the highest yield. Similarly, no trend was identified between lumber yield and log diameter (*fig. 3*), moisture content, or specific gravity. Plots of yield with these factors resulted in plots similar to *figure* 3.

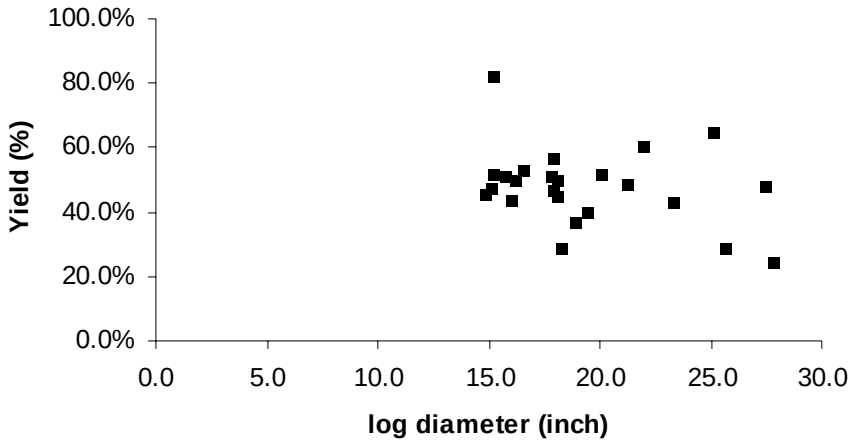

Figure 3 – Green lumber yield by log diameter.

Discussion

The collection yards have been successful in collecting *P. ramorum* infested wood. The Marin County collection yard was the most active, with the support of at least a dozen tree service companies and the county of Marin. The Santa Cruz collection yard was very active during the Santa Cruz County hazard tree removal project but it proved to be a challenge to encourage the local tree service companies to participate in the collection program. These yards have collected about 1200 green tons of woody biomass from sudden oak death host trees, mostly tanoak (~ 80 percent) and coast live oak (~ 15 percent). The potential for this material having viable *P. ramorum* spores is higher than in the general population of host material because the yards only accepted material that exhibited the combination of symptoms associated with the disease. However, since the presence of *P. ramorum* was not positively identified in each tree the yards undoubtedly accepted some dead and dying trees that were *P. ramorum* free.

The high correlation between the deliveries of host woody biomass to the yards and the bark beetle count inside the collection yard suggests that even though the beetles may not be a vector for *P. ramorum*, they are highly associated with the *P. ramorum* infested wood. Because most of the wood delivered was from hazard trees that were dead for more than 4 months, it is suggested that the beetles were not attracted to the wood once in was in the yard but rather they came into the yard in the dead wood. Also, since the beetle counts in the traps away from the yard did not show a corresponding rise, the beetles did not appear to spread far from the collection yard. Although the relationship between massive beetle attack and tree death is not fully understood, this evidence of large numbers of beetles associated with the wood

collected suggests that the beetles play an important role in the disease complex and further study is needed.

The data gathered from the collection yard activities and the periodic sampling for *P. ramorum* in and around the collection yard will be used in future studies to analyze the risk of spreading *P. ramorum* by transporting and processing biomass and wood products. Although *P. ramorum* was found in 23 of the 418 specimens collected (~ five percent), all of the positive cultures, except for firewood, were collected in unprocessed material at the collection yard or at the primary processing equipment (grinders and saws). Although no positive cultures have been obtained at the end uses of biomass power plant fuel, firewood air-dried longer than 6 months, or in processed lumber, the eight positive cultures collected from the fresh split firewood and the one positive from the partially dried firewood emphasize the need to further study the survivability of *P. ramorum* in processed firewood. It is encouraging that none of the firewood specimens dried longer than 6 months have tested positive. Also of interest is the observation that about 2/3rds of the positive *P. ramorum* cultures were collected during the winter and early spring months, the rainy months. This data suggests that *P. ramorum* is most active during the wet weather season of the year and that the risk of spreading *P. ramorum* is higher during these months.

The final evaluation of the potential lumber quality of *P. ramorum* infested logs cannot be reported until the analysis of the kiln-dried lumber is complete. However some preliminary observations are possible. The average specific gravity of 0.57 and the average green moisture content (MC) of 85 percent are slightly lower than the previously reported values of 0.60 specific gravity and 90 percent MC, but is certainly within the range of expected normal variation (Shelly and Jackovics 2001). The 48 percent yield of green lumber reported in this study is markedly lower than the 60 percent green lumber conversion previously reported by Shelly and Jackovics (2001). The extra deterioration of wood quality from the decay and insect infestations in the logs surely accounts for this lower yield. The final conclusions cannot be made until the kiln dried lumber is evaluated for quality but the yield is expected to decrease another five to ten percent as a result of drying defects created during kiln drying. This suggests that although lumber can be produced from *P. ramorum* infested trees, the expected low yield of high quality lumber may limit the economic potential.

Summary

The data reported on in this study indicate that viable *P. ramorum* spores can be collected from dead and dying sudden oak death host trees that are delivered to

collection yards. However, no evidence has been gathered to support the hypothesis that the collection, sorting, and processing activities in the collection yards influences *P. ramorum* infestation levels at the site.

Biomass powerplant fuel and lumber are considered good uses for *P. ramorum* infested wood if care is taken in isolating the grinder dust and sawdust generated during processing. Firewood may be a good use but more information is needed to understand the survivability of *P. ramorum* in firewood. The relative ranking of these options as a best use is dependent on the expected value of the product and any extra costs associated with handling the material to limit the risk of pathogen spread. This economic potential will be evaluated in future work.

Acknowledgements

This project could not have been successfully implemented and managed without the assistance cooperation of the many individuals on the project Coordinating Committee (complete list posted at http://groups.ucanr.org/SODBusters) representing the California Department of Forestry and Fire Protection, California Integrated Waste Management Board, California Department of Food and Agriculture, and the Marin County and Santa Cruz County Agricultural Commissioners Offices. A special thanks to Don Gasser, Pacific Gas and Electric Company for spearheading the early discussions of the disposal and utilization of *P. ramorum* infested wood; Cynthia Murray, Marin County Supervisor for her early support of the project; Joe Garbarino and John Oranje, CEO and Vice President of the Marin Resource and Recovery Center; Patrick Mathews, Santa Cruz Department of Public Works and Mitch Matsumoto of Vision Recycling, Inc. for their help in operating the collection yards; Cheryl Blomquist, California Department of Food and Agriculture for her assistance in the DNA identification of *P. ramorum* cultures; Don Owen, California Department of Forestry and Fire Protection for his assistance with the interpretation of bark beetle activity; and last but certainly not least, the California Oak Mortality Task Force staff members Janice Alexander, Karl Buermeyer, and Katie Palmieri for their assistance in public outreach, training, and information dissemination. This project was funded by the California Department of Forestry Agreement No. 8CA01257 with assistance from the USDA Forest Service, State and Private Forestry.

References

Anon. 2002. *Phytophthora ramorum*; **Quarantine and Regulations**. Federal Register. 7 CFR Part 301 (docket no. 01-054-1). US Government Printing Office; 6827-6837.

Anon. 2005. **Oak Mortality Disease Control**. California Code of Regulations. Register 2005, No. 3. Section 3700. January 21, 2005. State of California.

Blomquist, C. and Kubisiak, T. 2003. **Laboratory diagnosis of *Phytophthora ramorum* from field samples.** Sudden Oak Death Online Symposium. www.apsnet.org/online/sod. American Phytopathological Society. doi:10.1094/SOD-2003-TK.

Davidson, J.M.; Rizzo D.M.; and Garbelotto M. 2002. ***Phytophthora ramorum* and sudden oak death in California: II. Pathogen transmission and survival.** In: Standiford R, McCreary D, Purcell K.B. (eds). Proc. 5th Oak Symposium: Oaks in California's Changing Landscape. Oct. 22-25, 2001. San Diego, CA. Gen. Tech. Rpt. PSW-GTR-184. USDA Forest Service, Pacific Southwest Research Station, Albany, CA.; 741-749

Erwin, D.C. and Ribeiro, O.K. 1996. **Phytophthora Diseases Worldwide**. St. Paul, MN: APS Press. 562 p.

Furniss, R.L. and Carolin, V.M. 1977. **Western Forest Insects**. Miscellaneous Publication No. 1339. Washington, DC: US Forest Service, Department of Agriculture; 654 p.

Garbelotto M. 2003. **Composting as a control for sudden oak death disease**. BioCycle: February 2003; 53 - 56.

Garbelotto, M.; Davidson, J.M.; Invors, K.; Maloney, P.E.; Huberli, D.; Koike, S.T.: and Rizzo, D.M. 2003. **Non-oak native plants are main hosts for the sudden oak death pathogen in California**. California Agriculture (57):1; 18 – 23.

Shelly, J.R. and Jackovics, K. 2001. **Tanoak Utilization: Coordination of Tanoak Recovery and Yield Studies and Knowledge Transfer**. University of California Forest Products Laboratory. Berkeley, CA. Technical Report Number 35.01.4xx. September 2001. 29 p.

Shelly, J.R.; Singh, R.; Langford, C.; and Mason, T. 2004. **Removal and utilization of high risk sudden oak death host material. Progress Report 3.** Internal Report, January 29, 2004. University of California Wood Resources Group, Richmond Field Station, Richmond, CA. 64 p.

Storer, A.J.; Keirnan K.E.; Palkovsky, N. K.; Hagen, B.W.; Slaughter, G.W.; and Kelly, N.M.; Svihra P. 2001. **Sudden Oak Death: Diagnosis and management**. Pest Alert #5. March 2001. University of California Cooperative Extension, Marin County, Novato, CA. 12 p.