Sudden Oak Death Management and Monitoring in the Bay Area
Forest Service Agreement No. 10-DG-11052021-214

Progress report Jan - May 2011

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Project objectives

Objectives for the project are listed below. This contract continues management and monitoring projects that began in 2008 under contract 08-DG-11052021-144. This project is jointly funded by the Midpeninsula Regional Open Space District (MROSD) for management projects on District lands. Funding for activities on San Francisco Public Utilities Commission (SFPUC) lands are provided entirely by SFPUC, and serve as matching funding for this project.

1	Continue management projects designed to protect vulnerable but currently non-diseased stands of tanoak by treating large forest patches with Agri-fos® via bark spray application in plots located at: A. SFPUC lands in the Peninsula Watershed near Crystal Spring Reservoir (Skyline Drive). B. MROSD El Corte de Madera Open Space Preserve.
2	Continue treatments and monitor effectiveness of the combined use of localized bay removal and Agri-fos® treatments for protecting large, high value oaks at: A. MROSD Rancho San Antonio Open Space Preserve (coast live oak). B. MROSD Los Trancos Open Space Preserve (canyon live oak)..
3	Monitor the effectiveness of area-wide bay removal to protect vulnerable stands of oaks at: A. MROSD Rancho San Antonio Open Space Preserve (coast live oaks) B. MROSD Monte Bello Open Space Preserve (Shreve oaks) C. SFPUC Pulgas Water Temple vicinity, Peninsula Watershed (coast live oaks) D. MROSD Russian Ridge Open Space Preserve (canyon live oak)
4	Monitor the effectiveness of cut stump herbicide treatments for suppressing bay resprouting in Rancho San Antonio Open Space Preserve and Monte Bello OSP.
5	Monitor the effectiveness of hack and squirt herbicide treatments for killing large bay in bay removal disease suppression projects at Monte Bello OSP
6	Collect data on long-term SOD monitoring plots established in 2000 (Marin, Sonoma, Napa Co.) to maintain data continuity on disease incidence, symptom progress, tree mortality, and tree failure.

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Summary of project activities

June-December 2010

Major project activities during the June-December 2010 period were related to objectives 1,2,3,4, and 6 and were covered in Progress Report 1. Project activities occurring in the first project reporting period are summarized below.

Annual Agri-fos spray applications were made at the following locations in November 2010:

- tanoak in plots at MROSD El Corte de Madera Open Space Preserve and SFPUC lands in the Peninsula Watershed near Crystal Spring Reservoir (Skyline Drive)

- canyon live oaks at MROSD Los Trancos Open Space Preserve

- coast live oaks at MROSD Rancho San Antonio Open Space Preserve

We re-evaluated disease status of monitored trees at the following locations:

- tanoak in Agri-fos treated and control plots at MROSD El Corte de Madera Open Space Preserve and SFPUC lands in the Peninsula Watershed near Crystal Spring Reservoir (Skyline Drive),

- canyon live oaks treated with bay removal and Agri-fos and control trees at MROSD Los Trancos Open Space Preserve,

- coast live oaks treated with bay removal and Agri-fos and control trees at MROSD Rancho San Antonio Open Space Preserve.

- area wide bay removal and control plots coast live oaks at MROSD Rancho San Antonio Open Space Preserve.

We recorded data on bay sprout regrowth at MROSD Rancho San Antonio Open Space Preserve.

We established plots to monitor the effectiveness of bay removal in preventing SOD on canyon live oaks at MROSD Russian Ridge Open Space Preserve. We obtained the first positive isolation of *P. ramorum* from a canyon live oak bole canker during this activity.

We collected data on long-term SOD monitoring plots established in 2000 (Marin, Sonoma, Napa Co.).

Koch's Postulates were completed for bole cankers caused by *P. ramorum* through field inoculations of canyon live oak and Shreve oak.

January-May 2011

Activities in the January-May 2011 period included the items listed below. Details of progress over the January-May 2011 reporting period are discussed in this report.

Coast live oaks at Rancho San Antonio Open Space Preserve were given their second Agri-fos injection treatment.

We continued to monitor symptom development on canyon live oaks inoculated with *Phytophthora ramorum*.

We used spore trapping to monitor the effectiveness of the bay removal treatments at three study locations.

We assessed the effectiveness of glyphosate hack and squirt treatments on large California bay at Monte Bello OSP. We also recorded data on bay sprout regrowth from glyphosate-treated stumps at this location.

Project locations and treatments

The projects set up on MROSD lands are summarized in Table 1. Because all of the sites are in the vicinity of the SOD management studies that we are conducting on the SFPUC watershed, it has been possible to coordinate some of the plot work at SFPUC sites with work at MROSD sites, reducing total travel-related costs.

Table 1. SOD management studies initiated on MROSD lands from 2008 through 2010.

Open Space Preserve	**Locality**	**Host species present** (bold= primary species)	**Treatment(s) and dates applied**	**Treated area sample size**	**Untreated area sample size**
El Corte de Madera (ECDM)	near gate CM06	**tanoak**, coast live oak, Shreve oak, canyon live oak	Agri-Fos stem spray application with removal of small understory tanoak: Jan 2009 May 2009 Nov 2009 Nov 2010	158 stems	164 stems
Monte Bello	Skid Road trail gate (MB06)	**shreve oak**, canyon live oak	areawide bay removal (includes hack and squirt bay treatments): Dec 2008, Mar 2009 July 2009 May 2010	97 stems	86 stems

Table 1 continued.

Open Space Preserve	**Locality**	**Host species present** (bold= primary species)	**Treatment(s) and dates applied**	**Treated area sample size**	**Untreated area sample size**
Rancho San Antonio (RSA)	permit lot area	**coast live oak**	Localized bay removal and Agri-Fos injection: Nov 2008, Jan 2011. Localized bay removal (Nov 2008) and Agri-Fos stem spray application: Jan 2009, May 2009, Nov 2009, Nov 2010 Areawide bay removal only: Nov 2008	9 stems* 14 stems* 42 stems	61 stems
Los Trancos	Near Page Mill Road, Franciscan Loop Trail and Fault Trail	**canyon live oak**, coast live oak	Localized bay removal (Dec 2009, April 2010) and Agri-Fos spray application: Nov 2009, April 2010, Nov 2010 Localized bay removal only: Dec 2009, April 2010	16 stems 9 stems	31 stems
Russian Ridge	Near Ancient Oaks Trail	**canyon live oak**	Localized bay removal only: Dec 2009, Sep 2010	34	36
Skyline	Rattlesnake Point area	**canyon live oak**	Inoculation of canyon live oak to complete Koch's postulates, observe symptom progresssion, assess isolation efficiency	18 canyon live oak, 2 Shreve oak	

* One sprayed tree was removed in 11/09. One injected stem of a multistemmed oak failed in 2009., and the three remaining stems were switched to spray application in 2010. As a result, the number of injected stems changed from 13 to 9 and sprayed stems from 11 to 14.

Rancho San Antonio Open Space Preserve

Due to the particular constraints and opportunities at this heavily used open space, we are testing multiple SOD management techniques at this location (Table 1).

Coast live oak - Agri-fos treatment and localized bay removal

Large high value oaks near a trail and creek were treated by conducting localized bay removal to the degree possible and treating the trees with Agri-fos either by high bole spray application (11 stems initially) or injection (13 stems initially) under our previous contract 08-DG-11052021-144. Bay removal was limited in this area because it was impractical and undesirable to remove many of the large bays along the creek. Bay

removal in the area was primarily limited to the removal of a dense understory of small bays, removal of a few larger bays, and pruning off some stems and branches of bays that were left in place.

Among this set of coast live oaks, one of the sprayed trees was removed by MROSD as a potentially hazardous tree in November 2009. One injected stem of a multistemmed tree failed in 2009. This changed the geometry of this large oak relative to the creek to make spray application feasible. Starting with the fall 2010 Agri-fos application, we switched the three remaining stems of this tree to spray application. As a result, the number of injected stems changed from 13 to 9 and sprayed stems from 11 to 14.

We used the Arborjet "Tree I.V." injection system for the initial injections in November 2008. Injections were made through a septum in a 0.95 cm diameter (3/8 inch) diameter plastic plug which is inserted into and remains in the outer sapwood. Hence, injections require drilling a 0.95 cm diameter hole through the bark (up to about 4 cm thick in the largest trees) into the sapwood.

Among the injected trees, none of the injection holes had closed after two years. Most injected trees showed some recent bleeding or oozing around some of the old injection holes, and a few had long bark cracks associated with these holes. Due to the slow closure and oozing associated with the injection points, we felt that the amount of damage associated with the injections was not acceptable for repeated injections over many years on a two year re-injection schedule.

After some research and inquiries, we obtained an alternative type of tree injector from ArborSystems (arborsystems.com). They provided a Wedgle Direct-Inject Quick Connect™ injection system with Portle® injection tips (figure 1). This system does not require drilling into the wood. Instead, the injector tips are driven directly into the bark with a slide-hammer (figure 2) and leave only a 1-2 mm diameter hole. The Portle® tips have a number of small holes along the sides of the tip which allow for chemical delivery into the inner bark, near the cambium. This system seemed better suited for treating the coast live oaks in that it caused smaller wounds and also placed material directly into the inner phloem and cambial region of the lower stem. Since this is the tissue affected by *P. ramorum* bole cankers, it is the most important site for expression of phosphite activity.

The ArborSystems kit came with multiple tips. After driving the tip into the tree, the injector is connected to the tip. The desired amount of chemical is pumped through the injector by squeezing the handles (figure 3). The ArborSystems Portle injector tips have a built-in check valve that prevents chemical from leaking back out of the tip until it is absorbed by the tree. Once the chemical is absorbed, the tips can be pulled from the tree.

Each pump of the injector nominally delivers 1 ml of liquid. We used a graduated cylinder to verify that the target amount of chemical was delivered through each tip (figure 3). This setup also allowed us to use a 1:1 dilution of Agrifos, rather than the full strength solution (620 g potassium phosphite/L), which is used in the ArborSystems prepackaged formulation. We believed that the 1:1 dilution would reduce the potential

for phytotoxicity. For the Arborjet Tree I.V. injections, Agri-fos is diluted 1:5 with water and for the Chemjet injectors a 1:2 dilution is used.

The ArborSystems injectors were used to treat only those trees previously injected using the ArborJet Tree I.V. injectors with the exception of the partially failed tree that was switched to a spray application. MROSD Open Space Technician Brian Fair assisted with the injections of the 9 coast live oaks, which was done on 14 Jan 2011. We injected 6 ml of 1:1 diluted Agri-fos solution at each injection point. The overall applied dose was 1.75 ml non-diluted Agri-fos (45.8% potassium phosphite) per inch DBH, which is the same rate as used with the Chemjet injectors. This required a spacing of 12-14 cm between injection points. Although the injection system generally worked well, it was not free of problems. We had difficulty maintaining the prime of the injector, which required additional pumps to deliver the desired volume, and some of the tips became plugged. Occasionally, injected material would leak from cracks in the bark above or below the injection point.

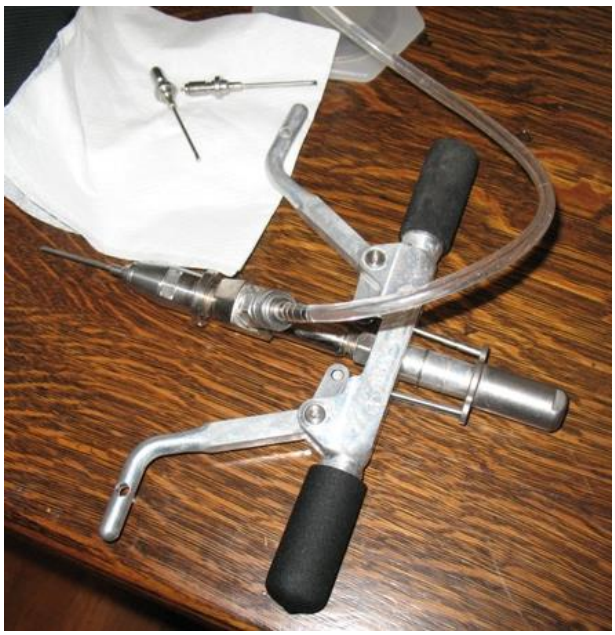

Figure 1. Arborsystems injector and tips.

Figure 2. Slide-hammer being used to drive injection tip into coast live oak at RSA.

Figure 3. Injection of coast live oak at RSA. Note injection tips in tree to left of injector. Injected phosphite solution was delivered through a length of plastic tubing from a graduated cylinder (top center) which allowed direct observation of the amount delivered.

Spore monitoring

To better understanding how well bay removal works to reduce inoculum levels near oaks, used we sand based spore traps (Figure 4) to monitor spore deposition during the period from 4 April to 26 May 2011. Spring rainfall is important for new oak infections as temperatures usually are more favorable for infection than the temperatures during winter rainfall. Spore traps were set up at Russian Ridge, Los Trancos, and Monte Bello Open Space Preserves. It was difficult to find areas where spore traps could remain undisturbed at Russian Ridge and Los Trancos due to the fact that treated trees with California bay removal are mostly located along trails.

Each trap consists of a plastic tray mounted on legs that drains through a PVC column containing 100 ml (160 g dry weight) of a sterile fine sand / loam mixture (5:1). *P. ramorum* propagules in rainwater that drips through the canopy is collected in the tray and diverted through the column. Lab studies have shown that *P. ramorum* propagules from the water are retained in the sand mixture and can survive for at least several weeks. Propagules in the sand are detected by direct plating and baiting of the sand mixture. Based on the amount of sand mixture plated, the theoretical threshold of detection for the soil plating method is about 1 cfu/7.5 ml sand mixture or about 13 cfu per column if

every viable propagule is detected. The actual detection threshold is likely to be somewhat more than 13 cfu/column. Lab tests have shown that baiting of the non-plated portion of the sand from the column can detect *P. ramorum* inoculum at concentrations below the detection threshold for plating.

Low-evaporation rain capture containers were set up adjacent to at least one spore trap at each location. The volume of water in these containers was used to calculate the amount of canopy throughfall that accumulated over the trapping period. This amount was used to estimate the total volume of water that passed through each column (based on tray area) and to estimate the number of cfu detected per unit volume of water (Table 2).

For this study, 2.5 ml aliquots of sand from each spore trap were placed on each of three PARP/hymexazol (PARPH) plates and the remaining sand from the traps was baited with 10 rhododendron leaf disks (figure 4). Plates from all bait-positive samples were completely scanned multiple times to identify and count *P. ramorum* colonies. On the PARPH plates, *P. ramorum* colonies were most reliably identified by sporangium production in the agar. We verified the identification of a sample of *P. ramorum* positive and negative colonies by transferring colonies to PARP and assessing resulting colonies for typical *P. ramorum* morphological characteristics. Results are reported below by location.

Figure 4. Upper left, spore trap being set up. Upper right, sand being emptied from spore trap. Lower left, aliquots of sand are placed on PARP/hymexazol media and spread out across the surface of the plate. The sand rinsed off after 4 days, by which time propagules in the mixture have germinated and started to grow into the agar. Lower right, sand baited with rhododendron leaf plugs. After 4 days leaf baits are placed into PARP/hymexazol (PARPH) agar to determine if they are infected by *P. ramorum*.

Los Trancos. Four traps were set up at Los Trancos (table 2). A rainwater collector attached to one of the spore traps measured 3.2 cm (1.25 inches) of throughfall rain during the 4 April - 26 May period. The trap at tree 1219 was evidently disturbed by a passerby but remained upright and intact. *P. ramorum* was detected in two of the traps by leaf baiting, including the trap at tree 1219, which had localized bay clearing (5.3 m oak-bay clearance). However, only one trap, located adjacent to a control tree, had enough inoculum to be detected via direct plating (Table 2). The other trap in the control area was under a very small understory bay, near a control tree with low bay cover (<25% cover) within 5 m.

Russian Ridge. Six traps were set up at Russian Ridge OSP. Three traps were close to canyon live oaks that had nearby bay removed as part of our study. The other three traps were near control canyon live oaks in untreated parts of the forest. Rainwater collectors attached to two different spore traps captured 5.7 cm (2.2 inches) and 3.4 cm (1.3 inches) of canopy throughfall from rain from 4 April to 26 May 2011. Only the traps in areas without bay removal had detectable *P. ramorum* (Table 2).

Monte Bello. Six traps were set up at Monte Bello OSP. Three traps were set up near Shreve oaks in the large area from which bay had been removed, and three traps were set up next to control Shreve oaks in untreated parts of the forest. A rainwater collector attached to one of the spore traps measured 3.7 cm (1.4 inches) of throughfall rain during the trapping period. *P. ramorum* was only detected in the three traps from the areas without bay removal (Table 2)..

Summary. These results indicate that both localized and area-wide bay removal has greatly reduced the amount of *P. ramorum* propagules that could have been deposited on the oak trunks during late spring rain storms. The amounts of spores detected in the traps varied both within and between locations. This factor likely contributes to the patchy distribution of disease that is commonly seen in infested areas.

In 2010, our spore trapping was limited to six traps at the Monte Bello OSP. We detected *P. ramorum* in only one of three traps placed in the control (no bay removal) area, and that detection was by baiting only. In contrast, *P. ramorum* was detected in all three traps in control area without bay clearing in 2011 (Table 2) and was detected by both baiting and direct plating. This suggests that inoculum production was greater in 2011 than in 2010, which is likely to translate into increased disease incidence in susceptible oaks that have been exposed to high amounts of *P. ramorum* propagules. Thus, our monitoring in 2011 and 2012 should begin to show whether the applied treatments have been effective at preventing SOD.

Table 2. Results of 2011 spore trapping at Los Trancos (LT), Monte Bello (MB), and Russian Ridge (RR) OSP. Shaded cells with 0 m bay clearance represent untreated controls. Remaining traps were next to trees in areas of either localized (LT, RR) or area wide (MB) bay removal.

Location	Tree	Closest bay (m)	Symptoms on bay leaves	*P. ramorum* detection by baiting / direct plating	Estimated cfu* per L water
LT	1246	0	Rare	Yes / Yes	767
RR	995	0	Common	Yes / Yes	25
RR	498	0	Common	Yes / Yes	16
RR	490	0	Common	Yes / Yes	10
MB	355	0	Common	Yes / Yes	3.2
MB	363	0	Common	Yes / Yes	3.2
MB	435	0	Common	Yes / Yes	3.2
LT	1192	0	Common	No / No	<0.28 (>3.6 L/cfu)
RR	489	2.8	Sparse	No / No	<0.20 (>5.1 L/cfu)
LT	1219	5.3	Common	Yes / No	<0.28 (>3.6 L/cfu)
RR	199	5.9	Present	No / No	<0.20 (>5.1 L/cfu)
RR	488	8.6	Sparse	No / No	<0.20 (>5.1 L/cfu)
LT	1212	9.2	Common	No / No	<0.28 (>3.6 L/cfu)
MB	321	>20	-	No / No	<0.24 (>4.1 L/cfu)
MB	332	>20	-	No / No	<0.24 (>4.1 L/cfu)
MB	334	>20	-	No / No	<0.24 (>4.1 L/cfu)

*cfu=colony forming unit, i.e., a viable *P. ramorum* propagule forming a colony on PARPH media

Canyon live oak – improving SOD diagnosis - Skyline Ridge Open Space Reserve

Methods. Our previous progress report described the procedures we used to inoculate and reisolate *P. ramorum* from canyon live oak in the field at Rattlesnake Point. As we described in our last report, we inoculated nine canyon live oaks in each of the two areas at this location. The lower plot area is a closed canopy stand dominated by relatively tall canyon live oaks with small, often thinning crowns, some of which are partially overtopped. This plot area has some intermixed tanoak and a few bay. Some of the bays have been removed since the inoculations were done. The upper plot area was a restoration planting, which also has a closed canopy, but trees are much shorter with wider crowns. Most canopies are relatively dense, and the lowermost branches are mostly dead or dying due to shading out. The stand includes canyon live oak, shreve oak, and a few tanoaks that were planted. The seed source(s) are unknown, but are probably from the Peninsula.

We also inoculated two Shreve oaks at the upper restoration site to act as positive controls. Each tree was inoculated with two different local *P. ramorum* isolates and a control (sterile agar only) inoculation. The three inoculation points were spread out as far as possible around the circumference of the trees, which averaged about 25 cm DBH. Symptoms have been evaluated periodically since the trees were inoculated..

Inoculated trees were sampled on 12 December 2010 and 30 April 2011. In December 2010, we sampled one Shreve oak and six of the canyon live oaks, three from each site. In April 2011, we sampled three canyon live oaks in the lower plot and two in the upper plot. Trees were sampled by shaving off the outer bark to expose the entire canker margin. Canker dimensions were measured above, below, and to each side from the inoculation plug and at 45 degree angles between these directions. In addition, canker outlines were traced onto sheets of clear plastic. The traced outlines were converted to digital images via scanning and analyzed using ImageJ software (version 1.45i) to determine canker areas.

After cankers were measured, tissue around the canker margin was sampled and placed onto PARP medium to reisolate the pathogen. To determine whether isolations were more effective from particular portions of the canker, sampled areas were numbered, marked, and recorded via digital photographs to document sampling locations. In most cankers, we also sampled at two depths. Most samples were collected at the typical sampling depth in the mid to outer live phloem tissue. A second set of samples were taken by cutting deeper in the bark and outer sapwood and sampling at the innermost margin of tissue discoloration.

On trees where it was possible, we attempted to completely excise all discolored areas from one of the two cankers associated with the inoculations. Canker excision has been suggested as a potential control methods for SOD, and these trees provided a means to do a limited evaluation of this technique on canyon live oak.

Symptoms. We found that few *P. ramorum* bole cankers on inoculated canyon live oaks bleed (Table 5). Overall, 9 of 36 (25%) of the inoculation points showed some bleeding through April 2011, but recent bleeding was never seen at more than 4 inoculation points (11%) at any given observation interval. When bleeding was present, it was present in miniscule amounts and for fairly short time periods compared to what is typical on infected coast live oaks. Only one tree (168, upper plot), which developed a massive canker by November 2010, had enough bleeding to be noticeable at any distance. These results are consistent with our field observations showing that evidence of bleeding is very uncommon in naturally infected trees. Because few cankers actually develop bleeding, bleeding occurs for only short periods, and the amounts of bleeding are very small, any evidence of bleeding will be difficult to detect or may wash off over time leaving no clear trace.

One of the four inoculation points on the two Shreve oaks showed bleeding by 12/10/10, and multiple bleeding spots were associated with all four Shreve inoculations by April 2011. Although the bleeding on the inoculated Shreve oaks was also limited, it was much more extensive than seen on the canyon live oaks.

Through the end of April 2011, the canopies of all trees were green and showed no significant thinning or dieback. In addition, no evidence of beetle activity or *A. thouarsianum* sporulation was seen on any of the trees.

Table 3 . Evidence of recent bleeding beyond the inoculation plug for canyon live oak and Shreve oak trees and inoculation points through 4/30/11. Note that the specific trees showing bleeding vary over time.

		Recent bleeding present at date assessed				
Species	**Totals**	**11/1/10**	**12/10/10**	**2/4/11**	**4/6/11**	**4/30/11**
Canyon live oak						
Trees (tag #))	18	3 (159,165,168)	3 (162,168,171)	0	3 (168,169,172)	3 (159,169,172)
Inoculation points	36	4	4	0	3	3
Shreve oak						
Trees	2	0	1	0	2	2
Inoculation points	4	0	1	0	4	4

Figure 5. Left and right, SOD cankers April 2011 on canyon live oaks inoculated July 2010. Left photo tree from upper plot, right photo tree from lower plot.

Using glyphosate to kill bays at Monte Bello

Hack and squirt applications to standing trees. A few bay trees in the Monte Bello bay removal area were too large or too difficult for CCC crews to safely fell. However, these trees were a safe distance from trails and MROSD staff decided to kill the trees

with glyphosate using the frill or "hack and squirt" technique. The killed stems would then be allowed to decay and fail over time in place.

Initial treatments were made on 9 March 2009 by Scott Cotterel (MROSD staff). Downward-angled cuts were made completely around the circumference of treated stems using a hatchet and glyphosate (20.5% ai solution) was immediately sprayed into the cuts using a backpack sprayer. On a subsequent trip to the area for data collection, we found three bays in the bay removal area had not been cut or treated by hack and squirt herbicide application. We notified Scott Cotterel about these trees, which were treated by hack and squirt application on 14 July 2009. At the same time, several trees that were not showing strong top symptoms were retreated. As discussed below, trees originally treated on 14 July 2009 received a second hack and squirt application of glyphoste in May 2010.

The hack and squirt treatment was fairly effective for the trees originally treated with herbicide in March 2009. Of the 13 bay stems treated, most showed complete topkill by 20 August 2009, with the remaining stems showing 80-98% topkill. By 23 November 2009, 7 of 13 treated stems were dead, 5 had more than 90% dieback, and one had at least 80% dieback. By May 2011, all 13 stems were dead.

In contrast, the three bays that were initially treated in July 2009 showed relatively little effect of the herbicide treatment. Some chlorosis developed by August 2009 and further chlorosis and some canopy thinning were evident by November 2009. However, these trees improved somewhat over the winter and were still in fair condition in March 2010. These three trees were retreated in May 2010. One of these trees was nearly dead in May 2011, largely due to complete girdling. The remaining trees were still alive and had a significant amount of foliage, which showed *P. ramoum* symptoms.

These results show a strong seasonal influence on the efficacy of hack and squirt glyphosate treatment. The July 2009 treatment had only minimal effects, whereas the March 2009 treatment was fairly effective. The May 2010 application may also have been later than optimum. We also noted that the second applications made in May 2010 were very close to the original treated area. If the newly treated areas were already damaged from the previous treatment, less uptake and translocation could result.

Based on both these results and results showing effective translocation and kill from glyposate treated stumps (Los Trancos), it appears that cut surface glyphosate treatments are most effective when made in the wet season, from about December to early March. We recommend that the bay trees that have survived the previous hack and squirt treatments at Monte Bello be retreated in late December or early January 2012.

Cut stump treatments. Similar to results previously reported for stumps monitored at RSA, glyphosate treatment of the cut stumps at Monte Bello was generally effective. We have followed resprouting of 14 bay stumps at Monte Bello. Two of these that were not treated with glyphosate showed vigorous sprouting. However, deer or other browsing animals have kept these sprouts hedged back, so that the maximum shoot height in summer 2011 was only 23 cm. Of the 12 glyphosate-treated stumps, 10 were completely

dead and had no live sprouts by summer 2011. Two treated stumps (6.5 and 60 cm diameter) had live shoots. Shoot heights were small (maximum shoot height 12 and 19 cm, respectively) due to both herbicide-related stunting and browsing.

These results suggest that glyphosate treatments of cut stumps greatly decrease bay stump sprouting. However, browsing alone can keep sprout heights low enough that repeat treatments may not be needed for extended periods. We have seen similarly strong suppression of regrowth by browsing at other locations where herbicides have not been used to suppress sprouting.