Evaluating threats posed by exotic *Phytophthora* species to endangered Coyote ceanothus and selected natural communities in the Santa Clara NCCP area

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EXECUTIVE SUMMARY

The goals of this project were to: (1) detect *Phytophthora* species that are either currently impacting or have the potential to seriously degrade populations of covered plants in the Plan Area, and (2) use this information to develop a management strategy to minimize introductions of pathogens and limit/contain impacts in affected areas. We developed a sampling strategy by using GIS data to determine where various priority habitat types with *Phytophthora*-susceptible vegetation might be exposed to *Phytophthora* contamination from roads, trails, past restoration plantings, or other known risk pathways. We also considered proximity to lands enrolled or proposed for enrollment in the NCCP reserve system, access, and in-field observations of vegetation symptoms and risk factors to determine sampling locations.

We collected 189 samples from Santa Clara County Parks, and Santa Clara County Open Space Authority preserves, and other reserve system areas with high-priority vegetation types. Sixty-eight samples were collected in extant populations of Coyote ceanothus (*Ceanothus ferrisiae*). An extensive, but still localized, infestation involving multiple *Phytophthora* species at Anderson Lake poses the greatest threat to any of the Coyote ceanothus populations at this time. Preventing spread of contamination from the infested area on the western Anderson Dam abutment to nearby stands should be a high priority. Additional detections of *Phytophthora* near the reservoir high-water line pose a long-term concern if the pathogens spread uphill from these areas. *Phytophthora* was recovered only from seasonal stream water below the Kirby Canyon Coyote ceanothus population and a pond edge adjoining the Llagas population. *Phytophthora* species detected in stream water and the pond edge differed from those infecting the upland stand of Coyote ceanothus on the Anderson Dam abutment. No *Phytophthora* species were found in the sampled Coyote ceanothus stands on Coyote Ridge.

Twenty *Phytophthora* taxa were identified across all samples. *Phytophthora* species were detected in 67% of 21 water samples collected across all sampled locations. These included spring-fed ponds where contamination may have been introduced via grazing livestock. Forty-four root/soil samples were collected from sites that are periodically flooded, and 124 root/soil samples were from uplands or flats and lowlands not subject to inundation. *Phytophthora* species were recovered from 59% of the periodically flooded sites, and 9% of samples of natural vegetation from drier upland and flat/lowland sites. About half of the upland and flat/lowland *Phytophthora* detections are associated with the *Phytophthora* infestation in native vegetation on the western abutment at Anderson Dam. Five samples from transplanted nursery stock (upland or flat/lowland sites) at four reserves yielded two *Phytophthora* detections.

Our baseline sampling indicates that *Phytophthora* infestations are uncommon in and near reserve system lands and are mostly associated with known risk factors for *Phytophthora* introduction. Because eradication of *Phytophthora* species within all but very small infested areas is difficult to impossible, management practices should emphasize prevention. This includes preventing introduction of additional *Phytophthora* species into habitat areas and preventing spread from existing infestations into additional areas. Best management practices to accomplish these management objectives are discussed in this report.

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Cover photo: View across Santa Clara Valley from Sierra Vista Open Space Preserve, 15 January 2018.

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1. INTRODUCTION

Phytophthora species are microscopic Oomycetes (water molds). Previously considered fungi, these microorganisms are more closely related to the brown algae than to true fungi. More than 120 *Phytophthora* species have been described to date, and virtually all are plant pathogens. Diseases caused by *Phytophthora* species include root rots, stem cankers, and blights of fruit and leaves. Host ranges of individual *Phytophthora* species may be relatively narrow or very wide, encompassing thousands of plant species in many unrelated families. The potential host ranges of most *Phytophthora* species are unknown because relatively few of these pathogens have been studied in depth, and most studies focus on disease problems in agricultural crops. When introduced into native ecosystems, various exotic *Phytophthora* species have proven to be serious to devastating pathogens (James 2011a,b, Hansen et al 2000, Henricot et al 2017, Jung and Blaschke 2004, Rizzo et al 2005, Swiecki et al 2011, Wills 1993). Sudden oak death, caused by *Phytophthora ramorum* and root rot caused by *P. cinnamomi* are two notable examples in California (Rizzo et al 2005, Swiecki et al 2011).

Recent research has highlighted the importance of diseases caused by exotic *Phytophthora* species in Bay Area and other northern California native habitats. In particular, many *Phytophthora* species have been detected in nursery stock planted into habitat areas in restoration projects in California (Bourret 2018, Rooney-Latham et al 2015a,b, Sims et al n.d., Swiecki et al 2015, 2017) and Oregon (Reeser et al 2012, Weiland 2015). This has greatly increased the chances that *Phytophthora* species will establish and spread in habitat areas, affecting the growth and survival of native species.

Root disease and plant mortality caused by exotic *Phytophthora* species pose a threat to the health, functioning, and sustainability of natural plant communities. Introductions of these pathogens into habitat areas within the Santa Clara Valley Habitat Plan area have the potential to directly affect listed plant species, such as Coyote ceanothus, or entire habitats that support other listed species. One such situation has already been seen near Anderson Lake Dam. Spread of the various introduced *Phytophthora* species from an infested area on the dam abutment into adjacent habitat poses a threat to the sustainability of the Coyote ceanothus population in that area. Threats posed by invasion of habitats by exotic pathogens were not directly addressed in the Conservation Strategy of the habitat conservation plan. However, they are broadly evaluated as part of the Nonnative Species or Disease changed circumstance.

In this project, we sampled to test for the presence of introduced *Phytophthora* species in natural communities within the plan area. Our goals were to: (1) detect *Phytophthora* species that are either currently impacting or have the potential to seriously degrade populations of covered plants in the Plan Area, and (2) utilize this information to develop management strategies to minimize introductions of *Phytophthora* pathogens into new areas and limit or contain impacts in affected areas. A key part of this effort was identifying plant communities that are most likely to be at risk for invasion by *Phytophthora.* High-risk plant communities that were identified as sensitive plant communities in the Natural Community Conservation Plan (NCCP) constituted the highest priority for observation and sampling in this project.

2. METHODS

2.1. Sampling strategy

We developed a conceptual framework for assessing the risk of *Phytophthora* introduction and spread based on disease epidemiology, vegetation, site factors, and land uses. Introduction risk was modelled as a multiplicative function of:
- *Phytophthora* inoculum density;
- the mass or volume of contaminated material transported by various processes; and
- site receptivity, which accounts for both host susceptibility and environmental factors that favor pathogen establishment.

Other host, pathogen, and environmental factors were coupled with this risk function to develop risk ratings specific to sites and/or land uses.

To prioritize potential sampling areas, we used a GIS-based analysis to assess the receptivity of plant communities and likely routes of contamination with parks, open space preserves, and other lands enrolled or proposed for enrollment in the NCCP reserve system (referred to as the reserve system or reserves in this document). To evaluate potential risks in these areas, we overlaid GIS layers for trails, road, and watercourses, source risk ratings, site receptivity ratings, and priority plant communities on aerial imagery of the reserves. We then evaluated these factors along with additional vegetation and land-use details visible in aeria*l* imagery using 3-D renderings of the landscapes to show relative elevations and drainage directions. All these factors were taken into account to identify priority areas for sampling. A detailed description of the process used to identify plant communities at risk for *Phytophthora* introduction was presented in our 30 November 2016 report to SCVHA. An updated version of that report is included in section 5 of this report.

When visiting field sites, the priority sampling areas identified in this process were used as a starting point. In-field observations related to risk factors, susceptible vegetation, and sensitive plant community types, as well as accessibility, affected final choice of sampling locations. Where present, vegetation showing symptoms consistent with Phytophthora root disease was sampled preferentially. However, plants with few or no obvious symptoms were sampled in areas considered to be at risk. Table 2-1 provides a summary of sampling conducted under this project.

2.2. *Phytophthora* detection and identification

2.2.1. Use of pears to bait *Phytophthora*

Because *Phytophthora* species can be difficult to isolate from diseased plants, plant pathologists have traditionally used various plant materials to bait *Phytophthora* from soil and water samples. Baiting takes advantage of the fact that *Phytophthora* species release swimming zoospores in the presence of free water. Zoospores detect and swim towards chemical attractants released from plant material. Once zoospores reach the plant material, they encyst, germinate, and initiate infections. Erwin and Ribeiro (2005) review the use of baits for detecting *Phytophthora*.

Different plant materials used for baits, including leaves, seedlings, and fruits, vary in their susceptibility to the various *Phytophthora* species. No single bait will detect all *Phytophthora* species. Among baits, green pears are readily available, are susceptible to many common and uncommon *Phytophthora* species, and are relatively easy to interpret based on the presence of visible lesions (Figure 2-1). Pears can be used to detect *Phytophthora* in soil samples, water samples, and root samples. It is important that pears be as green and blemish free as possible. *Phytophthora* species are among the few organisms that can infected green, unwounded pears. Other species, such as *Pythium* species, can infect ripe pears, and wounds on green pears. The presence of many blemishes on the pear skin can results in numerous *Pythium* lesions on the pear (if *Pythium* is present in the sample), which can make it more difficult to detect *Phytophthora* lesions.

Table 2-1. Samples collected for this project by location.

Location	**Sampling dates**	**Number root/soil samples**	**Number water samples**
Anderson Lake County Park *Ceanothus ferrisiae* populations	17 March 2017 18 and 27 December 2017 17 January 2018	32	1
Coyote Ridge *Ceanothus ferrisiae* population	4 November 2016	8	0
Kirby Canyon *Ceanothus ferrisiae* population	24 October 2016 17 January 2018	17	5
Llagas *Ceanothus ferrisiae* population	26 October 2016	10	0
Almaden Quicksilver County Park	14 April 2017	8	0
Calero County Park - north	17 August 2016	16	
Calero County Park - south	10 April 2017 29 December 2017	10	3
Coyote Lake/Harvey Bear Ranch County Park	18 December 2017 10 January 2018	12	4
Coyote Valley Open Space Preserve	28 June 2017 15 January 2018	7	0
Joseph D. Grant County Park	21 December 2017	9	0
Pacheco Creek Reserve	17 May 2017	8	2
Palassou Ridge OSP	29 March 2017 17 May 2017	4	5
Santa Teresa County Park	10 April 2017 28 June 2017	12	1
Rancho Cañada de Oro Open Space Preserve	28 June 2017 6 and 29 December 2017	11	0
Sierra Vista Open Space Preserve	15 January 2018	4	0
	Total number of locations	*15*	*7*
	Total number of samples[1]	**168**	**21**

[1]Total samples=189.

2.2.2. *Phytophthora* identification using nucleotide sequencing

Dr. Latham of CDFA provided species definitions based on information in PhytophthoraDB.org, a curated database of sequences based at Pennsylvania State University. This resource was infected with a computer virus in fall 2017 and is currently unavailable. CDFA identifications made after that point utilized PhytophthoraID.org, a curated database maintained by the Grünwald lab, Horticultural Crops Research Laboratory, USDA-ARS, Department of Botany and Plant Pathology, Oregon State University. In addition, some nucleotide sequences have been checked by Dr. Latham and ourselves against the noncurated collection at the National Center for Biotechnology Information, U.S. National Library of Medicine (referred to as NCBI or GenBank). This large collection of sequences is not curated, but is the standard depository for genetic sequences for published and unpublished research. The supplemental tables at the end of this report present the CDFA sequence identification numbers for each *Phytophthora* culture submitted for identification.

Identification of *Phytophthora* isolates to species level for this project was based on genetic sequencing of the internal transcribed spacer (ITS) regions of nuclear ribosomal RNA (rRNA) between the 18S gene, the 5.8S gene, and the 28S gene. The genes are clustered together and separated by the ITS regions, i.e., 18S gene — ITS1 — 5.8S gene — ITS2 — 28S gene. Although the nucleotide sequences of the genes have little variation between species, the order of nucleotides in the ITS regions are highly variable between species and thus extremely useful for distinguishing *Phytophthora* species. Other genes can also be sequenced to aid identification.

When a new species is described, a type culture is designated. Many *Phytophthora* species were named and described prior to the advent of nucleotide sequencing. Hence, for many decades *Phytophthora* species were identified based on microscopic features as well as host ranges and cardinal temperatures for growth and reproduction. As a result, many isolates were assigned to species that subsequent genetic analyses have shown to be species complexes. Newer species descriptions of some species discuss acceptable variations in ITS sequences. For other species, it is unclear how much variation in the sequence is acceptable. For example, if the ITS sequence of an unknown varies by a single nucleotide (base pair) or two from that of a known species, is it still the same species? The answer to this question varies by the species and is discussed in the results presented below. ITS sequences uploaded to GenBank may not represent the species assigned to the sequence if the original species designation was based solely on morphological characters. This is primarily a problem for species that have few if any distinguishing morphological features and were described before the routine use of nucleotide sequencing. In addition, some of the type cultures for species described in the early 1900s have been lost over time, and no designated types exist today.

Over the course of this study, the fee structure for DNA sequencing by the CDFA lab changed substantially. At the study start CDFA charged $30 a culture for sequencing the ITS and COX2 gene regions, but the cost for sequencing each individual gene has since increased to $70-$80 per culture. As a result, we discontinued routinely requesting COX2 sequences for submitted cultures, so only ITS sequences are available for most of our isolates.

2.2. Water samples

Water samples were collected by skimming the surface of the water with pivoting plastic sampling vessel on an extendable pole (Figure 2-1). Each water sample consisted of 5 to 8 separate skimmed subsamples that were combined in a heavy duty 1-gallon zip-closure bag containing a green D'Anjou pear. Pears were selected to be as blemish free as possible. The total water volume of each sample was about 2.5 L. Sample bags were supported in plastic containers and were placed in a cooler for transport. Upon return to the laboratory, sample bags were opened and placed in an incubator that cycled diurnally from 20 C (night) to 24.5 C (day). After three days of incubation, pears were removed and rinsed with tap water and incubated on clean paper towels in trays for up to 5 days. Isolations were made from lesions on pears as described below for root/soil samples.

Figure 2.1. Top - Collecting water sample at Pacheco Creek Reserve. Lower left - Pear and water sample in plastic bag at time of collection. Lower right – Brown lesions on pear are *Phytophthora* symptoms that developed after three days of incubation (note: this positive sample was not from the Pacheco Creek Reserve).

2.3. Root/soil samples

During the dry season, root/soil samples were collected by first scraping away organic debris and loose surface soil with a trowel. For dry soil, we used a shovel and the blade end of a mason's hammer to break up the soil to a depth of about 10-20 cm and collected soil and associated roots from this loosened soil. For damp soil, we were able to dig samples readily with a narrow trenching shovel and/or trowel. We emphasized the collection of live and dead root pieces in all samples, which are more likely than is the bulk soil to be associated with *Phytophthora* inoculum. Samples generally consisted of 3 to 6 subsamples taken around the root zones of sampled plants and totaled about 1 to 1.5 liter in volume. Samples were collected in 1-gallon heavy duty zip-closure plastic bags. Samples were placed in a cooled insulated container for transport back to the laboratory. Sampling tools were thoroughly cleaned and disinfested with 70% isopropanol between all samples.

Charcoal-filtered tap water was added to samples to bring soil to field capacity and create favorable environmental conditions for sporangium production. Root/soil samples were then incubated for 3 to 3.5 days at 20-24.5 C to allow time for sporangia to form before being flooded and baited with green D'Anjou pears. Samples collected in winter at cool ambient soil temperatures were also incubated at 3 to 3.5 days at 20-24.5 C to promote sporangium formation before baiting even if soil moisture was near field capacity. Samples from saturated areas (e.g., pond edges) were flooded and baited directly upon return to the lab without a preincubation period.

Each pear bait was washed with a dilute detergent solution and thoroughly rinsed before use. Pears were labeled with the sample number and placed into a slight depression created in the center of the soil sample in the collection bag. Roots in each sample were clipped with sterilized scissors as necessary to ensure that they did not extend above the water level after the sample was flooded. Water was added to flood each sample to a depth of about 4-5 cm above the soil level in the bag. Flooding stimulates release of zoospores that can infect the pears. It is likely that pears can also be infected directly by other propagules such as directly germinating sporangia, chlamydospores, and mycelium that are near the pear.

Pears remained in the flooded soil for up to 5 days at the 20-24.5 C temperature regime. Pears were removed before 5 days if *Phytophthora* symptoms developed before this time. Typically, symptoms did not develop until after at least 3 days of incubation. During the incubation period when pears were checked, the soil/root sample in the bag was manipulated to mix portions of the sample from the bottom of the bag into the upper portion of the sample. This was done to increase the likelihood that that inoculum that might be present at the bottom of the sample would not be completely restricted by the overlying soil.

Pears were rinsed with tap water upon removal from the sample bags and incubated on clean paper towels in trays at room temperature. Pears that did not develop symptoms by 8 days from the start of baiting were considered to be negative for *Phytophthora*. Symptomatic pears were photographed and the pathogen was isolated from lesions that developed on the pears. To obtain *Phytophthora* isolates, pears were first surface-disinfested by placing them in 0.5% NaOCl (diluted bleach) for 30-45 seconds. Pieces from the edges of suspect *Phytophthora* lesions were cut out using aseptic technique and placed into carrot agar in petri dishes. Mycelium that grew out of the tissue pieces was examined periodically with a microscope. Initial identification was based on morphology of mycelium and spores. Representative cultures for each observed suspected *Phytophthora* morphotype were sent to Dr. Suzanne Latham, Senior Plant Pathologist at the Plant Pest Diagnostics Lab, Plant Health and Pest Prevention Services, CDFA for identification by DNA sequencing of the ITS region of nuclear ribosomal RNA (rRNA).

3. RESULTS AND DISCUSSION

A total of 20 *Phytophthora* taxa (including described species, provisional species, and undescribed taxa) were detected during sampling for this project. These are listed in Table 3.1.2. Nearly all the *Phytophthora* taxa we recovered were already described in the scientific literature or matched ITS sequence data of unpublished provisional species that had been uploaded to GenBank. *Phytophthora* taxa are commonly given provisional names that are used in the scientific literature until species descriptions are formally published. Several of our isolates are identified with the suffix "-like" because ITS sequences differed from the published sequences by one or two base pairs and published information was insufficient to determine whether our variant could be considered the same taxon or an undescribed close relative (Table 3.1.2). Species complexes are noted for *P. cryptogea* and *P. megasperma* isolates that did not match the type species but do match other named isolates in GenBank. These species, described before the advent of genetic sequencing, have many isolates in GenBank that have ITS sequences up to 6 or more base pairs different from the type species and doubtless represent undescribed, possibly closely related species. Brief descriptions for all species and taxa recovered are listed in Section 6. Genetic sequencing results for recovered isolates is given in tables presented in the narratives for each sample location (Sections 3.2 and 3.3).

We recovered one species that does not have any published sequence and is considered to be an undescribed species. We gave this species the provisional name *P*. taxon agrifolia when we first isolated it from a *Quercus agrifolia* nursery stock planting site in a restoration project in San Mateo County in 2016. It was found in this study in two widely-separated, dissimilar sites, suggesting that *P*. taxon agrifolia may have been present in the area for an extended period. We are planning to describe this species formally in collaboration with researchers at UC Davis and CDFA. Section 6 describes what is known about host ranges and symptoms for each *Phytophthora* species recovered in this study.

In a recent study by researchers at University of California, Davis, root/soil samples were collected from outplanted nursery stock at 31 restoration sites in Santa Clara County (Bourret 2018). They detected 38 *Phytophthora* species from 191 samples collected at mostly riparian planting locations (Bourret 2018). This is more than twice the number of species that we recovered from 169 terrestrial samples. The greater diversity of *Phytophthora* detected by the UC Davis researchers in large part reflects the fact that they sampled nursery stock almost exclusively, whereas our sampling focused primarily on naturally-established vegetation. Nursery stock has a very diverse mix of *Phytophthora* species, which is further increased by sampling material produced over multiple years and by various nurseries (Bienapfl and Balci 2014, Parke et al 2014, Rooney-Latham et al 2015). Furthermore, because new *Phytophthora* species are continually being introduced into nurseries over time, the establishment of *Phytophthora* species into native habitats typically lags their original introduction in the nursery trade.

3.1. *Phytophthora* detections relative to site moisture regime

To examine how site factors related to *Phytophthora* presence, sample results were cross-tabulated against various factors. Based on field notes and images, we characterized each sample site according to its topographic and hydrological setting and then grouped these into three moisture categories as shown in Table 3.1.1. The water category includes all water samples, whereas the other two categories divide the soil/root samples into wetter sites that are seasonally or periodically flooded, and dry sites that are not subject to inundation. Note that sites characterized as dry may become saturated during periods of rainfall and may undergo intermittent ponding (mainly flat/lowland) or be exposed to surface runoff originating upslope. The moisture categories are color coded blue (water), green (periodic flooding), and orange (dry) in this table and other tables in this section.

Table 3.1.1. Moisture categories assigned to specific sample site types in this report.

Site moisture category		
Water	**Periodic flooding**	**Dry**
puddle	ravine/swale	flat/lowland
pond	floodplain	upland
reservoir	waterbody edge	
seasonal runoff	trail	
seasonal stream		
% of *Phytophthora* positive samples within category		
67%	59%	9%

3.1.1. Water samples

Sixty-seven percent of the water samples collected yielded at least one *Phytophthora* species (Figure 3.1.1). *Phytophthora* species were detected in water samples from all locations except from Pacheco Creek Reserve, where no *Phytophthora* species were detected in two separate water samples collected from the flowing creek in May 2017. Eight *Phytophthora* species were detected from the 21 water samples. The total diversity of species found in water for this project is much less than that found in sampled waterways downstream from restoration sites and housing in the San Jose area. *P. gonapodyides, P. lacustris* complex, and *P. chlamydospora* were each detected in water samples from three different locations (Tables 3.1.2 and 3.1.3). *P. gonapodyides, P. lacustris* complex, and *P. chlamydospora* were also detected in root/soil samples from sites that are periodically inundated. This indicates that these species either persist in soil for some time after flooding or survive by invading roots or other organic matter in soil. The other species detected in water (*P. acerina, P. crassamura, P.* taxon forestsoil-like, *P. megasperma,* and *P. ramorum*) were found in one location each. *P. crassamura* was detected in ephemeral runoff in a roadside ditch, whereas others were from larger streams. Each of these species, with the exception of *P.* taxon forestsoil-like, are known as plant pathogens of various plants. *P.* taxon forestsoil-like is known from a river in Taiwan; the ITS sequence of our isolates differs by one base pair from the Taiwan *P.* taxon forestsoil-like isolate.

3.1.2. Root/soil samples from sites with periodic flooding

Phytophthora was baited from periodically-flooded sample locations at 12 of the 13 locations where such sites were sampled. Overall, *Phytophthora* species were recovered from 59% of the 44 root/soil samples collected in sites subject to periodic flooding. Among sites grouped in this moisture category (Table 3.1.1), those at the edge of a waterbody were most likely to test positive for *Phytophthora* species (Figure 3.1.1).

Sites subject to periodic flooding also had the greatest diversity of *Phytophthora* species (Table 3.1.3). Sixteen of the 20 species isolated in this study were found in such sites. Of these 16 species, 9 species are members of *Phytophthora* clade 6 (Table 3.1.3). *Phytophthora* species are grouped into clades of closely related species based on genetic similarities (e.g., Yang et al 2017). As a group, members of clade 6 have good saprophytic ability and often inhabit aquatic or wetland ecosystems. Members of clade 6 are commonly detected in surveys of river and streams, but the pathogenicity of many of these aquatic species is not well documented. Other *Phytophthora* clade 6 species are commonly found in terrestrial sites. *Phytophthora megasperma* is perhaps the best known plant pathogen in clade 6, and causes root rots in many species.

The most frequently isolated species in periodically-flooded sites was *P. crassamura* (Table 3.1.3). Four locations tested positive for *P. crassamura*. As noted above, we recovered *P. crassamura* from ephemeral runoff water at Coyote Lake Harvey Bear County Park (Table 3.1.4). A similar detection was made in another part of the same park, where we recovered *P. crassamura* from mud picked up on boots on a wet section of trail shortly after a rain. These finds suggest that the species can be readily spread under wet conditions via surface runoff and tracking of wet surface soil (Table 3.1.2). We also detected this species in upland (dry site) samples of roots/soil collected under declining plants on either side of Anderson Lake Dam (Table 3.1.5, Figure 3.2.2-2 in Section 3.2.2 below).

P. crassamura is a primarily-terrestrial clade 6 species that was described recently (Scanu et al 2015) as a root pathogen of native species in Sardinia (Italy). Isolates of *P. crassamura* were previously assigned to *P. megasperma,* which is morphologically similar and closely related. *P. crassamura* has been detected recently in northern California in nursery stock planted at habitat restoration sites as well as in nurseries (Sims n.d.). Bourret (2018) detected it in samples from restoration sites in Santa Clara County. It is a homothallic species that forms thick-walled oospores. These resistant spores probably enhance its ability to survive when moved in contaminated soil.

P. gonapodyides was detected in samples nearly as often as *P. crassamura* and was detected at more locations (Table 3.1.3). *P. gonapodyides* was detected in five periodically-flooded soil/root samples from four locations and in water samples from two other locations (Table 3.1.2). *P. gonapodyides* is also likely to occur in water at the three locations where it was detected only in soil/root samples. This species can be isolated from asymptomatic plant roots and has been detected in California nursery stock (Bienapfl and Balci 2014). It has good saprophytic abilities and appears to naturalize when introduced into new aquatic environments.

P. gonapodyides, *P. lacustris* complex, and *P. chlamydospora,* the most frequently detected species in water (Table 3.1.3) were not recovered from water samples in the creek at Pacheco Creek Reserve, but all three were recovered from a root/soil sample from *Artemisia douglasiana* growing in the floodplain. This was the only detection in an intermittently flooded site for *P. lacustris* complex. *P. chlamydospora* was also recovered from a sample containing roots of dead *Ceanothus ferrisiae* and *Arctostaphylos glauca* plants that were temporarily inundated when the Anderson Lake reached its high-water level in early 2017.

P. inundata, another clade 6 species, was found in four periodically flooded samples in three locations. ITS sequences differed by one or two base pairs between isolates from different locations. Other clade 6 species found in periodically flooded sites at two locations included *P.* taxon raspberry, and *P. riparia*. Clade 6 species *P. asparagi* and a species in the *P. megasperma* complex were found at one location each (Table 3.1.2, 3.1.3).

Other *Phytophthora* species found at periodically-inundated sites belong to other clades. These included several well-known terrestrial plant pathogens: *P. cactorum, P. cambivora,* a species in the *P. cryptogea* complex, and *P. multivora.* The other detected taxa were *P. europaea*-like, *P. pseudocryptogea*, and *P.* taxon agrifolia. *P. pseudocryptogea* was described in 2015, *P. europaea*-like is an inexact match to a known pathogen, and P. taxon agrifolia is an undescribed species, as noted above. Hence, little is known about the pathogenicity or host ranges of these three taxa.

3.1.3 Dry samples

The majority of our samples were collected from sites characterized as dry, due to the emphasis in this study on Coyote ceanothus, which only occurs in upland locations. Among sampled natural vegetation in the two topographic positions classified as “dry”, we detected *Phytophthora* in 17% of flat/lowland samples compared to 8% of samples from upland sites (Figure 3.1.1.). *Phytophthora* was detected at five of the 15 locations where flat/lowland or upland sites were sampled (Table 3.1.3, Figure 3.1.2).

P. cambivora was the most widely distributed species detected, occurring at five locations. At one of these locations, it was found on planted nursery stock near a parking area, but other detections were in native habitats. *P. cambivora* was most frequently linked to presence of *Quercus* species in this study. We have previously detected *P. cambivora* in association with declining *Q. lobata* and *Q. agrifolia*, other hardwood trees, and native shrub species at multiple northern California locations. *P. cambivora* has been detected frequently in stock from California restoration nurseries (Latham et al 2016).

P. cambivora and several other *Phytophthora* species were also detected in the stand of Coyote ceanothus and other chaparral species on the west Anderson Lake dam abutment. This multispecies *Phytophthora* infestation is likely due to the planting of infected Coyote ceanothus nursery stock for habitat restoration at that site in 1993. Other *Phytophthora* species found in the Coyote ceanothus stand on the dam abutment in this study include *P. cactorum*, *P. crassamura*, and *P. megasperma* complex. In previous sampling in this area for SCVWD in 2015, we detected *P. cryptogea* complex and *P. syringae,* as well as *P. cactorum,* and *P. cambivora*. Overall, the detection of, and diversity of, *Phytophthora* species in upland species on the Anderson Dam abutment was higher than at any other upland location (Figure 3.1.3, Table 3.1.5).

Spread of *Phytophthora* from this infested area into nearby Coyote ceanothus stands has been a concern since the infestation was identified. In this survey, *P. crassamura* was detected along the Lake View trail on the south side of the lake in January 2018 sampling. However, it is not clear whether this apparently localized infestation is due to contamination introduced from the west dam abutment or another area infested with *P. crassamura*. Notably, no *Phytophthora* species have been detected to date in the stands north of the spillway or on Coyote Ridge. Other *Phytophthora* detections at Anderson Lake are discussed in further detail in section 3.2.1 below.

P. pseudocryptogea and *P*. taxon ohioensis-like were found in one location each in flat/lowland positions (Table 3.1.4). *P. pseudocryptogea* was recently described and little is known about its pathogenicity. *P*. sp. ohioensis is an undescribed species from Eastern United States isolated from oak forests. It has also been detected in a survey of declining street trees in Australia (Barber et al 2013).

P. cactorum was found on transplanted *Prunus ilicifolia* at Pacheco Creek Reserve. *P. cactorum* is a well-known pathogen with a wide host range that is common in nursery stock.

Table 3.1.2. *Phytophthora* species (or taxa) detected by location, sample site types, and plant roots present in root/soil samples. Multiple plant species present within a sample are separated by commas. A dash (-) is used to separate samples with different plant species combinations.

Phytophthora detected	Location	Sample site type	Plant roots present in sample
acerina	Kirby Canyon	seasonal stream	water
asparagi	Anderson Lake County Park	waterbody edge[1]	*Ceanothus ferrisiae*
cactorum	Anderson Lake County Park (dam abutment)	upland[1]	*Ceanothus ferrisiae, Heteromeles arbutifolia*
	Pacheco Creek Reserve	flat/lowland-nursery transplants	*Prunus ilicifolia*
	Sierra Vista Open Space Preserve	ravine/swale	*Platanus racemosa, Artemisia douglasiana, Scrophularia californica*
cambivora	Anderson Lake County Park (dam abutment)	upland[1]	*Ceanothus ferrisiae, Heteromeles arbutifolia*
	Calero County Park - south	ravine/swale	*Quercus lobata*
	Coyote Lake Harvey Bear County Park	flat/lowland	*Quercus lobata, Quercus agrifolia, Heteromeles arbutifolia*
	Coyote Lake Harvey Bear County Park	upland	*Quercus lobata, Toxicodendron diversilobum, Pinus sabiniana*
	Joseph Grant County Park	upland- nursery transplants	*Quercus kelloggii*
	Rancho Cañada de Oro Open Space Preserve	upland	*Quercus douglasii*
chlamydospora	Anderson Lake County Park	reservoir	water
	Anderson Lake County Park	waterbody edge[1]	*Ceanothus ferrisiae, Arctostaphylos glauca*
	Calero County Park - south	seasonal stream	water
	Pacheco Creek Reserve	floodplain	*Artemisia douglasiana*
	Santa Teresa County Park	seasonal stream	water
crassamura	Anderson Lake County Park (dam abutment)	upland[1]	-*Artemisia californica* -*Artemisia californica, Solanum umbelliferum*
	Anderson Lake County Park	upland[1]	*Heteromeles arbutifolia, Artemisia californica, Baccharis pilularis*
	Anderson Lake County Park	waterbody edge[1]	-*Baccharis pilularis* -*Ceanothus ferrisiae* -*Ceanothus ferrisiae, Arctostaphylos glauca* -*Ceanothus ferrisiae, Artemisia californica*
	Coyote Lake Harvey Bear County Park	seasonal runoff	water
	Coyote Lake Harvey Bear County Park	trail	mud and leaves
	Rancho Cañada de Oro Open Space Preserve	ravine/swale	*Quercus lobata*
	Sierra Vista Open Space Preserve	ravine/swale	*Quercus lobata, Quercus agrifolia*

***Phytophthora* detected**	**Location**	**Sample site type**	**Plant roots present in sample**
cryptogea complex	Santa Teresa County Park	ravine/swale	*Eleocharis, Quercus lobata, Artemisia douglasiana*
gonapodyides	Anderson Lake County Park	reservoir	water
	Anderson Lake County Park	waterbody edge[1]	*Ceanothus ferrisiae*
	Joseph Grant County Park	waterbody edge	*Salix sp, grass, Mentha pulegium*
	Pacheco Creek Reserve	floodplain	-*Artemisia douglasiana* -*Platanus racemosa, Conium maculatum, Bromus diandrus, Cirsium vulgare*
	Palassou Ridge Open Space	floodplain	*Platanus racemosa, Quercus agrifolia, Toxicodendron diversilobum*
	Coyote Lake Harvey Bear County Park	puddle	water
	Kirby Canyon	puddle	water
	Kirby Canyon	seasonal stream	water
inundata	Calero County Park - north	waterbody edge	forbs, grass, *Eleocharis*
	Santa Teresa County Park	ravine/swale	-*Artemisia douglasiana, Quercus lobata, Rosa californica, Sambucus nigra* ssp. *caerulea* - *Artemisia douglasiana, Baccharis pilularis, Elymus*
	Llagas Coyote ceanothus habitat	waterbody edge[1]	*Carex* or *Cyperus, Cynodon dactylon, Ceanothus ferrisiae, Frangula californica, Juncus xiphioides, Paspalum distichum*
lacustris complex	Anderson Lake County Park	reservoir	water
	Kirby Canyon	seasonal stream	water
	Kirby Canyon	seasonal stream	water
	Pacheco Creek Reserve	floodplain	*Artemisia douglasiana*
	Palassou Ridge Open Space	river	water
megasperma complex	Anderson Lake County Park	waterbody edge[1]	*Ceanothus ferrisiae*
	Anderson Lake County Park (dam abutment)	upland[1]	*Artemisia californica, Baccharis pilularis*
	Palassou Ridge Open Space	river	water
multivora	Santa Teresa County Park	floodplain	*Umbellularia californica, Quercus agrifolia*
pseudocryptogea	Coyote Lake Harvey Bear County Park	flat/lowland	*Acacia* sp., *Eucalyptus* sp.
	Santa Teresa County Park	ravine/swale	*Quercus lobata, Rosa californica, Artemisia douglasiana, Sambucus nigra* ssp. *caerulea*
	Sierra Vista Open Space Preserve	ravine/swale	*Quercus lobata*, grass
ramorum	Calero County Park - south	river	water

***Phytophthora* detected**	**Location**	**Sample site type**	**Plant roots present in sample**
riparia	Coyote Valley Open Space Preserve	waterbody edge	watercress, grass, *Salix sp.*
	Joseph Grant County Park	waterbody edge	*Salix* spp.
taxon agrifolia	Anderson Lake County Park	waterbody edge	*Ceanothus ferrisiae*
	Rancho Cañada de Oro Open Space Preserve	ravine/swale	*Quercus lobata*
taxon europaea-like	Santa Teresa County Park	floodplain	*Umbellularia californica, Quercus agrifolia, Quercus lobata*
taxon forestsoil-like	Kirby Canyon	seasonal stream	water
taxon ohioensis-like	Rancho Cañada de Oro Open Space Preserve	flat/lowland	*Quercus lobata, Toxicodendron diversilobum, Frangula californica*
taxon raspberry	Calero County Park - north	waterbody edge	-crabgrass, bermudagrass, monocots - forbs, grass, *Eleocharis*
	Joseph Grant County Park	waterbody edge	*Salix sp.*, grass, *Mentha pulegium*

[1]Coyote ceanothus habitat

Table 3.1.3. *Phytophthora* species by detection frequency and site moisture category. The clade of each *Phytophthora* species (Yang et al 2017) is also shown.

		Number of positive samples			Number of positive locations				
Total positive samples	**Taxon**	**dry**	**periodic flooding**	**water**	**Total positive locations**	**dry**	**periodic flooding**	**water**	**clade**
11	*crassamura*	3	7	1	4	1	4	1	6b
10	*gonapodyides*	0	6	4	6	0	4	3	6b
7	*lacustris* complex	0	1	6	4	0	1	3	6b
6	*cambivora*	5	1	0	5	4	1	0	7a
5	*chlamydospora*	0	2	3	4	0	1	3	6b
4	*inundata*	0	4	0	3	0	3	0	6a
3	*cactorum*	2	1	0	3	2	1	0	1a
3	*megasperma* complex	1	1	1	2	1	1	1	6b
3	*pseudocryptogea*	1	2	0	3	1	2	0	8a
3	taxon raspberry	0	3	0	2	0	2	0	6b
2	*riparia*	0	2	0	2	0	2	0	6b
2	taxon agrifolia	0	2	0	2	0	2	0	8
1	*cryptogea* complex	0	1	0	1	0	1	0	8a
1	*acerina*	0	0	1	1	0	0	1	2c
1	*asparagi*	0	1	0	1	0	1	0	6
1	taxon europaea-like	0	1	0	1	0	1	0	7a
2	taxon forestsoil-like	0	0	2	1	0	0	1	6
1	*multivora*	0	1	0	1	0	1	0	2c
1	taxon ohioensis-like	1	0	0	1	1	0	0	4
1	*ramorum*	0	0	1	1		0	1	8c
Totals									
189	Total samples collected	**124**	**44**	**21**					
53	Total *Phytophthora* positive*	**14** 11%	**26** 59%	**13** 67%					
68	Number of samples in Coyote ceanothus habitat	**55**	**12**	**1**		**4**	**2**	**0**	
15	Number of sampled locations	**15**	**13**	**7**		**5**	**12**	**6**	
20	Number of *Phytophthora* taxa	**6**	**16**	**7**					

*Numbers above will not sum to these totals because multiple samples contained more than one *Phytophthora* species. Includes natural vegetation and transplanted nursery stock.

Table 3.1.4. Sample site types, *Phytophthora* species detected, and location.

Sample site type	***Phytophthora*** **species detected**	**Location**
WATER		
puddle	*gonapodyides*	Coyote Lake Harvey Bear County Park, Kirby Canyon
seasonal runoff (road)	*crassamura*	Coyote Lake Harvey Bear County Park
seasonal stream	*acerina*, forestsoil-like, *gonapodyides, lacustris* complex	Kirby Canyon
	chlamydospora	Calero County Park - south, Santa Teresa County Park
reservoir	*chlamydospora*, *gonapodyides*, *lacustris* complex	Anderson Lake County Park
river	*lacustris* complex, *megasperma* complex	Palassou Ridge Open Space
	ramorum	Calero County Park - south
INTERMITTENT FLOODING		
waterbody edge	*asparagi, chlamydospora, crassamura, megasperma* complex, taxon agrifolia	Anderson Lake County Park
	gonapodyides	Anderson Lake County Park, Joseph Grant County Park
	inundata	Calero County Park - north, Llagas Coyote ceanothus population
	riparia	Coyote Valley Open Space Preserve, Joseph Grant County Park
	taxon raspberry	Calero County Park - north, Joseph Grant County Park
floodplain	*chlamydospora, lacustris* complex	Pacheco Creek Reserve
	gonapodyides	Pacheco Creek Reserve, Palassou Ridge Open Space
	multivora, taxon *europaea*-like	Santa Teresa County Park
ravine/swale	*cactorum*	Sierra Vista Open Space Preserve
	cambivora	Calero County Park - south
	crassamura	Rancho Cañada de Oro Open Space Preserve, Sierra Vista Open Space Preserve
	cryptogea complex, *inundata*,	Santa Teresa County Park
	pseudocryptogea	Sierra Vista Open Space Preserve
	taxon agrifolia	Rancho Cañada de Oro Open Space Preserve
trail	*crassamura*	Coyote Lake Harvey Bear County Park

Sample site type	***Phytophthora* species detected**	Location
DRY		
flat/lowland	*cambivora, pseudocryptogea*	Coyote Lake Harvey Bear County Park
	taxon ohioensis-like	Rancho Cañada de Oro Open Space Preserve
flat/lowland transplant	*cactorum* (from transplanted nursery stock)	Pacheco Creek Reserve
upland	*crassamura*	Anderson Lake County Park (Lake View trail and west dam abutment)
	cactorum, megasperma complex	Anderson Lake County Park (west dam abutment)
	cambivora	Anderson Lake County Park (west dam abutment), Coyote Lake Harvey Bear County Park, Rancho Cañada de Oro Open Space Preserve
upland transplant	*cambivora* (from transplanted nursery stock)	Joseph Grant County Park

Table 3.1.5. Sample locations, sample site types, number of samples with and without *Phytophthora* detected, and identity of *Phytophthora* species detected.

		Number of samples		
Location	**Sample site type**	**Neg**	**Pos**	***Phytophthora* species detected**
Almaden Quicksilver County Park	upland	8	0	
Anderson Lake County Park (other than dam abutment)	reservoir	0	1	*chlamydospora, gonapodyides*, *lacustris* complex
	waterbody edge[1]	3	6	*asparagi, chlamydospora, crassamura, gonapodyides, megasperma* complex, taxon agrifolia
	upland[1]	10	1	*crassamura*
Anderson Lake County Park west dam abutment	flat/lowland	1	0	
	upland[1]	6	5	*cactorum, cambivora, crassamura, megasperma* complex
Calero County Park - south	pond	1	0	
	seasonal stream	0	1	*chlamydospora*
	river	0	1	*ramorum*
	ravine/swale	0	1	*cambivora*
	flat/lowland	3	0	
	upland	6	0	
Calero County Park - north	waterbody edge	2	2	*inundata*, taxon raspberry
	upland	12	0	

		Number of samples		
Location	**Sample site type**	**Neg**	**Pos**	***Phytophthora* species detected**
Coyote Lake Harvey Bear County Park	pond	1	0	
	puddle	0	1	*gonapodyides*
	seasonal runoff (road)	0	1	*crassamura*
	seasonal stream	1	0	
	trail	0	1	*crassamura*
	flat/lowland	1	2	*cambivora, pseudocryptogea*
	flat/lowland nursery stock	1	0	
	upland	6	1	*cambivora*
Coyote Ridge Coyote ceanothus population	upland[1]	8	0	
Coyote Valley Open Space Preserve	waterbody edge	0	1	*riparia*
	ravine/swale	3	0	
	upland	3	0	
Joseph Grant County Park	flat/lowland	1	0	
	upland	5	0	
	upland transplant	0	1	*cambivora* (from transplanted nursery stock)
	waterbody edge	0	2	*gonapodyides, riparia*, taxon raspberry
Kirby Canyon	puddle	0	1	*gonapodyides*
	seasonal stream	0	3	*acerina*, forestsoil-like, *gonapodyides*, *lacustris* complex
	ravine/swale	1	0	
	upland transplant	1	0	
	upland[1]	12	0	
Pacheco Creek Reserve	river	2	0	
	floodplain	1	2	*chlamydospora*, *gonapodyides*, *lacustris* complex
	flat/lowland transplant	1	1	*cactorum* (from transplanted nursery stock)
	flat/lowland	3	0	
Palassou Ridge Open Space	seasonal stream	1	0	
	river	1	3	*lacustris* complex, *megasperma* complex
	floodplain	3	1	*gonapodyides*

		Number of samples		
Location	**Sample site type**	**Neg**	**Pos**	***Phytophthora* species detected**
Rancho Cañada de Oro Open Space Preserve	ravine/swale	0	1	*crassamura*, taxon agrifolia
	flat/lowland	3	1	taxon ohioensis-like
	flat/lowland transplant	1	0	
	upland	4	1	*cambivora*
Santa Teresa County Park	seasonal stream	0	1	*chlamydospora*
	floodplain	2	2	*multivora*, taxon *europaea*-like
	ravine/swale	2	3	*cryptogea* complex, *inundata*, *pseudocryptogea*
	flat/lowland transplant	1	0	
	upland	2	0	
Sierra Vista Open Space Preserve	ravine/swale	0	3	*crassamura, cactorum, pseudocryptogea*
	flat/lowland	1	0	
Llagas Coyote ceanothus population[1]	waterbody edge[1]	0	1	*inundata*
	upland[1]	9	0	

[1]Coyote ceanothus habitat

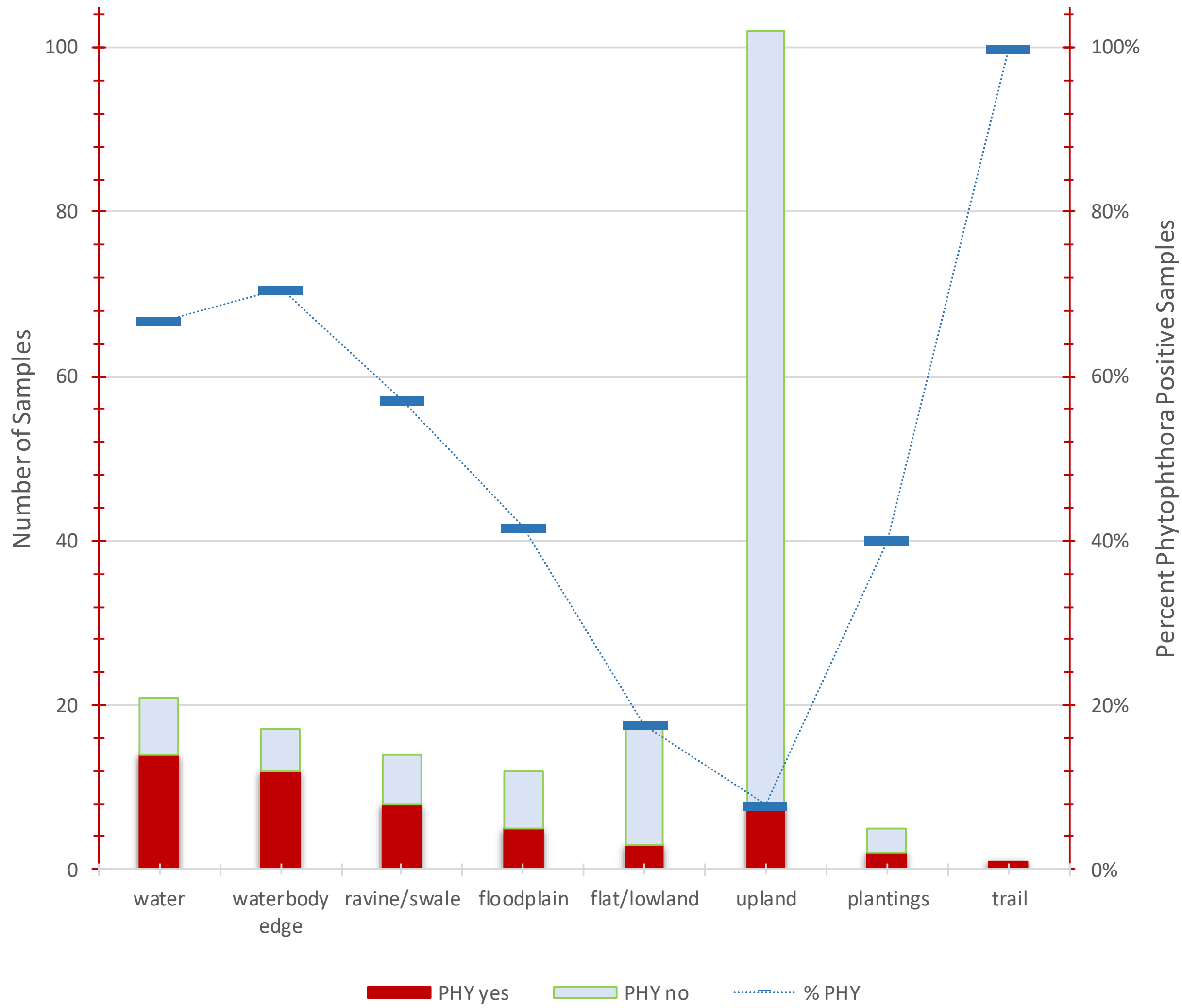

Figure 3.1.1. Number of samples with and without *Phytophthora* detections (bars) and percent of *Phytophthora*-positive samples (horizontal lines) by sample type.

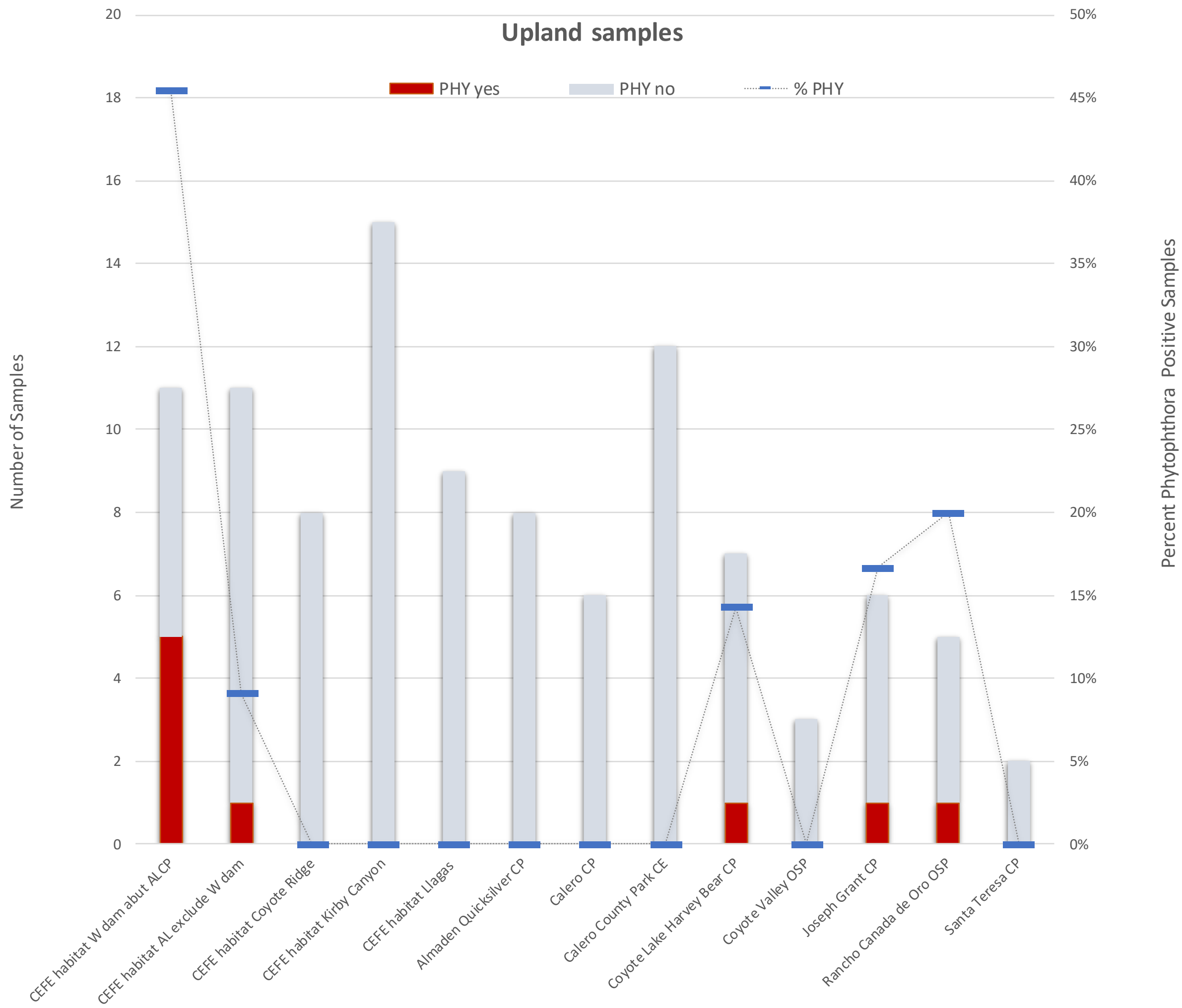

Figure 3.1.2. Number of upland samples with and without *Phytophthora* detections (bars) and percent of *Phytophthora*-positive samples (horizontal lines) by location. *Ceanothus ferrisiae* habitat locations are on the left.

3.2. Test Coyote ceanothus populations for *Phytophthora*

Details of the *Phytophthora* sampling conducted in the three *Ceanothus ferrisiae* population areas (Anderson Lake, Kirby Canyon, and Llagas) are presented in this section.

3.2.1. Anderson Lake population

Background

Sampling conducted for the Santa Clara Valley Water District in 2015 revealed that the *Ceanothus ferrisiae* habitat on the dam abutment at Anderson Lake was contaminated with a mix of *Phytophthora* species. No *Phytophthora* species were detected in *C. ferrisiae* habitat north of the spillway at that time (Figure 3-1.1-1).

Phytophthora contamination on the dam abutment was traced to a restoration planting in 1993 that used nursery-grown *C. ferrisiae* transplants. Survival of *C. ferrisiae* planted in the 1993 restoration plantings was variable. Wood chip mulch and basins were still present at many sites, and at one sample location (AD18) we found a discarded Deepot container. Many of the transplanted *C. ferrisiae* were dead, and some sites were entirely empty. Most of the dead plants were relatively short, about 0.5 m or less. Given that dead plants were still present in some locations more than 20 years after planting, it appeared that a number of these plants survived for some years before dying. Mortality of *Heteromeles arbutifolia* and *C. ferrisiae* was observed around all planting locations. *Phytophthora cactorum* was detected in 8 of the 13 samples collected in or near planting basins; *P. cambivora* was also detected in two of these eight samples. A strain in the *P. cryptogea* complex was detected in two samples and *P. syringae* was detected in one sample. Detections were widely distributed throughout the planted area (Figure 3-1.1-1).

Sampling details

For this project, we expanded the sampling locations for the Anderson Lake population of *C. ferrisiae* to determine the extent of the *Phytophthora* infestation on the dam abutment and to look for additional infestations. We sampled the stands of *C. ferrisiae* in the eastern unit of Anderson Lake County Park on 17 March 2017 (AD24 - AD29). The lake levels were still extremely high, and we were unable to reach the *C. ferrisiae* stand that is only accessible from the lake shore. We collected one water sample from the boat landing among partially submerged *Baccharis pilularis* plants (AD23). On the same date, we collected samples from the dam abutment area to further delineate the extent of the *Phytophthora* infestation in that area (AD30-AD35). Samples were collected beyond the area previously sampled for Santa Clara Valley Water District.

On 18 December 2017, we sampled the small stand of *C. ferrisiae* that grows along the lake shore southeast of the dam (AD36-AD39). At that time, the lake level was about 23 m (75 ft) below the Anderson Dam spillway. Numerous *C. ferrisiae* had become established in the bare lake shore below the main stand. The reservoir level has been kept at a low draw-down condition (60% capacity or less) since approximately 2009 because of seismic restrictions placed on the dam. These plants had been inundated during high water levels in the reservoir in early 2017 and were dead. We collected one sample from the root systems of dead plants and three other samples from larger individuals growing along or above the high-water line near the spillway elevation (190.5 m=625 ft).

We resampled this area on 27 December 2017 after detecting *Phytophthora* in the previously-inundated dead plant sample. At this sampling date, we collected samples from dead *C. ferrisiae* individuals and other nearby plants along the lake high water line on both the east (AD40-AD41) and west (AD46-AD47) sides of the dam. One sample (AD42) was collected among dead *Baccharis* near the point where we had previously sampled water when the lake was near the high water in March 2017 (AD23). We also collected samples from *C. ferrisiae* plants in the area north of the spillway and on the dam abutment (AD43-AD51).

We sampled a few additional sites on 17 January 2018. Two points were sampled along the Lake View trail near the Anderson Lake parking area (AD52 and AD53), and three points were sampled west of Coyote Rd (AD54-AD46) to help delineate the western edge of the *Phytophthora* infestation on the dam abutment.

All Anderson Lake sample locations are shown in Figure 3.2.1-2 and samples are described in Table 3.2.1-1. Identification details for *Phytophthora* species determinations are given in Table 3.2.1-2.

Coyote Ridge stand
We sampled the Coyote Ridge stand of *Ceanothus ferrisiae* northwest of Anderson Dam on 4 November 2016. Sample locations are shown in Figure 3.2.1-3 and samples are described in Table 3.2.1-3.

Sampling results
No *Phytophthora* was detected in samples collected in the eastern unit on 17 March 2017. *Phytophthora* was detected in samples collected from the dam abutment area and the reservoir water sample. The water sample from the reservoir yielded three species of *Phytophthora*, all of which we have found in other waterways in the San Jose area. Strains in the *Phytophthora lacustris* complex appear to be the most common *Phytophthora* species in waterways in the San Jose area. We have recovered *P. chlamydospora* and *P. gonapodyides* much less frequently. No *Phytophthora* had been detected in a previous water sample we tested from the same area of Anderson Lake in 2015, when reservoir levels were much lower (AD08). However, we had detected a strain in the *P. lacustris* complex from a water sample collected several hundred meters downstream from the dam in Coyote Creek on 25 March 2015 (AD22, Figure 3.2.1-3).

P. cambivora, detected at sample point AD30, was previously detected on the dam abutment in association with dying and declining *Ceanothus ferrisiae* and *Heteromeles arbutifolia* (sample points AD18 and AD06, Figure 3.2.1-1).

We had noted a patch of dead *Artemisia californica* when sampling 25 March 2015. At that time, we did not detect *Phytophthora* in a root/soil sample collected at point AD12. The area of dead *A. californica* had expanded by 2017, and newly wilting plants were seen around the margins of the area (sample point AD32). In addition, another area of dead and declining *A. californica* was noted on one of the terraces near the Serpentine Trail (sample point AD33). *P. crassamura* (originally identified as *P. megasperma*) was isolated from root/soil samples from both locations. We had not previously recovered this species from the dam abutment area. This find increased the number *Phytophthora* species detected in association with dead and declining native vegetation on the west dam abutment to five: *P. cactorum*, *P. cambivora*, *P. cryptogea* complex, *P. crassamura*, and *P. syringae*. This high *Phytophthora* diversity in a relatively small area is consistent with introduction by means of the restoration nursery stock of *C. ferrisiae* that was planted on the abutment in 1993. All the detected species are known to occur in nurseries.

Upland areas were sampled to determine whether *Phytophthora* species from the infested dam abutment have spread into nearby Coyote ceanothus stands. In January 2018 sampling, we detected *P. crassamura* in association with symptomatic toyons on the Lake View trail south of the dam (AD53, Figure 3.2.1-4). To date, this is the only upland sampling site away from the infested area on the dam abutment where *Phytophthora* has been detected. This sample was collected in a relatively flat area next to an unpaved road/trail and just below another side trail and is a site where infested soil could have been deposited by park users (pedestrians, equestrians) or by park vehicles. The source of inoculum for this apparently localized infestation could be the dam abutment. However, *P. crassamura* has been found in multiple locations in the reserve system (Table 3.1.3) and undoubtedly occurs in developed landscapes in the area, so the contamination could also have come from outside the park. This additional infestation beyond the dam abutment increases the potential for *P. crassamura* to be spread to Coyote ceanothus habitat south of the dam via movement of contaminated soil along trails. This find also emphasizes the risk to the Coyote ceanothus stand north of the spillway, which is closer to the infested areas on the abutment. The lack of established trails into that area has likely played a major role in preventing spread of the *Phytophthora* into that stand to date.

We detected an unexpected diversity of *Phytophthora* species among *Ceanothus ferrisiae* and other woody species along the reservoir's high-water line in samples collected in December 2017 (Figure 3.2.1-5). This zone is an unusual environment. Its original condition was a steep midslope upland. It has remained a dry slope for years because low lake levels have been maintained since about 2009. Record rains in early 2017 raised the reservoir level to above the spillway, and the plants that had established into this dry slope environment were for a short time at water's edge or were shallowly flooded. It is not clear whether the periods of saturation and inundation experienced by plants in this area would have been lethal. However, the detection of multiple *Phytophthora* species associated with the roots of these dead plants suggests that they were functioning as in-situ whole plant baits for *Phytophthora*, and it is likely that these pathogens contributed to the demise of the plants.

The presence of clade 6 species *P. gonapodyides* and *P. chlamydospora* in these plants was not surprising, especially given the detection of both species in the March 2017 water sample collected near flooded *Baccharis pilularis* near the boat ramp (AD23). However, the prevalence of *P. crassamura* and detections of *P. asparagi* and *P.* taxon agrifolia were not anticipated. *Phytophthora* had not been detected in samples collected near the high-water line north of the dam in 2015. No *Phytophthora* was detected in December 2017 samples collected above the high-water line (AD36, AD38, AD39), so the detections in plants along the high-water line most likely originated from inoculum carried in the water. A likely source of this inoculum is a residential development above the west shore of the lake's south arm (Holiday Lake Estates), the edge of which is about 1.1 km from the sampled areas south of the dam. Runoff from the development would flow directly into the lake during heavy rainfall. Given the amount of nursery stock planted around the houses in this development, runoff would likely contain *Phytophthora* inoculum from multiple species. Especially when high water levels were reached in 2017, runoff including spores and infected plant debris would have been channeled past the sampling sites.

Although this lake shore infestation is associated with an unusual event, it has the potential to pose a long-term risk to the Coyote ceanothus stands close above the lake shore on both sides of the dam. If *Phytophthora* infections have spread into roots of some plants on the base of the slope next to the high-water line, *Phytophthora* could begin to spread upslope via root infections.

A summary of all *Phytophthora* sampling results for the Anderson Lake Coyote ceanothus population is shown in Figure 3.2.1-6.

Coyote Ridge stand

Phytophthora was not detected in any of the samples on Coyote Ridge (Figure 3.2.1-3). We had previously visited and sampled this population 22 July 2015 for a different project and had also not detected *Phytophthora* in any samples at that time.

Figures and Tables

Figure 3.2.1-1. Location of sampling sites in 2015 at Anderson Dam. *Phytophthora cactorum, P. cambivora, P. syringae*, and/or *P. cryptogea* complex were detected at sample locations shown in red; others were negative for *Phytophthora*. Pink inverted droplet icons are locations of known 1993 nursery stock plantings of *Ceanothus ferrisiae* (based on information provided by SCVWD staff; location near AD18 was adjusted based on field observations during sampling in March 2015).

Figure 3.2.1-2. Locations for *Phytophthora* samples collected at Anderson Dam. Blue pushpins mark sites of 1993 nursery container stock plantings of *Ceanothus ferrisiae*. Other icons mark sampling locations. White and yellow icons indicate negative samples; pink and red icons indicate a *Phytophthora* detection. Pink and yellow pushpins icons mark soil/root samples collected for this project. White and red circles are locations of soil/root sample collected for SCVWD in February and March 2015 (also shown in Figure 3.2.1-1). The inverted droplet icons mark water samples (AD08 from March 2015 and AD23 from March 2017). Water level exceeded spillway height during spring 2017 when AD23 was collected. Sample descriptions and *Phytophthora* species identifications are in Tables 3.2.1-1 and 3.2.1-2. Image date 11/2/2016.

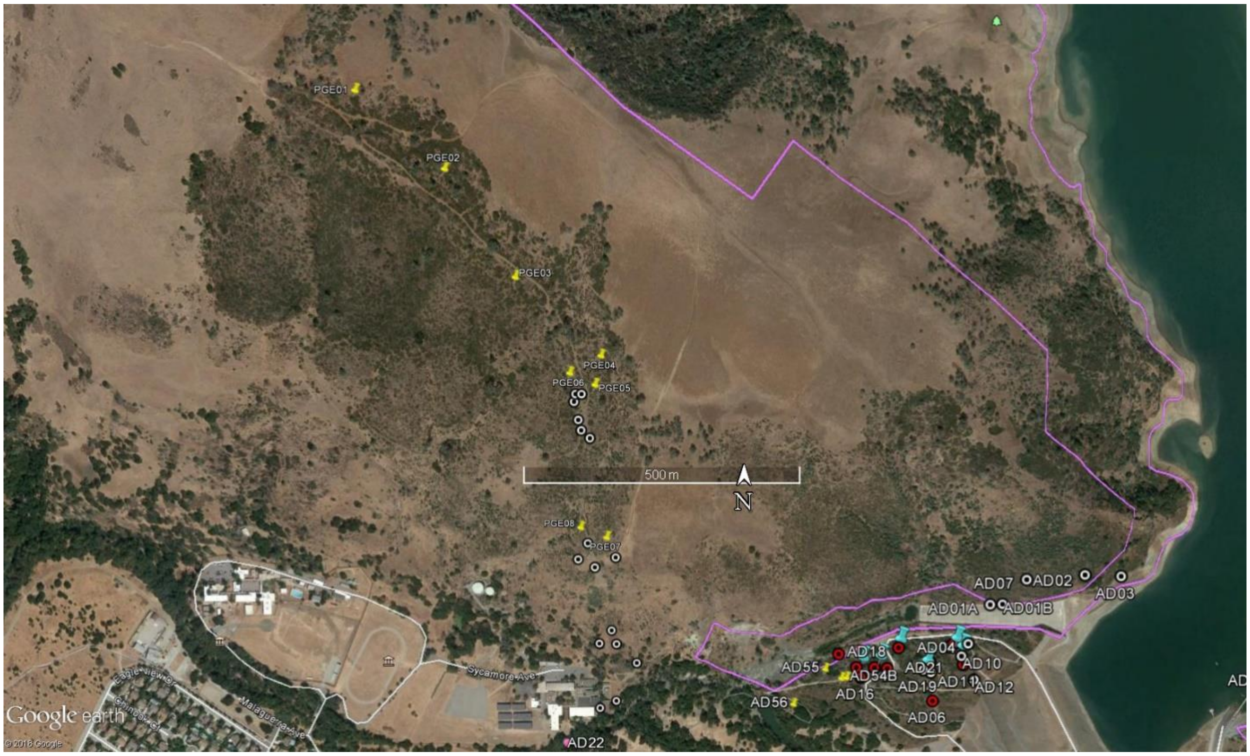

Figure 3.2.1-3. Sample locations for 4 November 2016 sampling of Coyote Ridge population of *Ceanothus ferrisiae* (points PGE01 through PGE08, yellow pushpins). *Phytophthora* was not detected at any of these sample points. Round white icons in this area mark samples collected 22 July 2015. These samples were also negative for *Phytophthora*. Icons on the lower right side of image are Anderson Dam area sample points described above.

Figure 3.2.1-4. *Phytophthora crassamura* was baited from roots and soil collected from beneath this declining toyon (*Heteromeles arbutifolia*) at sample point AD53, along the Lake View trail south of Anderson Dam. The trail is visible in the foreground at left; a second trail is present just upslope from this site. Image date 1/17/2018.

Figure 3.2.1-5. In December 2017, many small dead *Ceanothus ferrisiae*, manzanitas, and other shrub species were noted in an area that was saturated or inundated in early 2017 when Anderson Lake overflowed the spillway amid heavy rains. Root/soil samples collected beneath dead plants in this zone yielded *P. asparagi*, *P. crassamura, P.* taxon agrifolia, *P. chlamydospora,* and *P. gonapodyides*. Image date 1/17/2018.

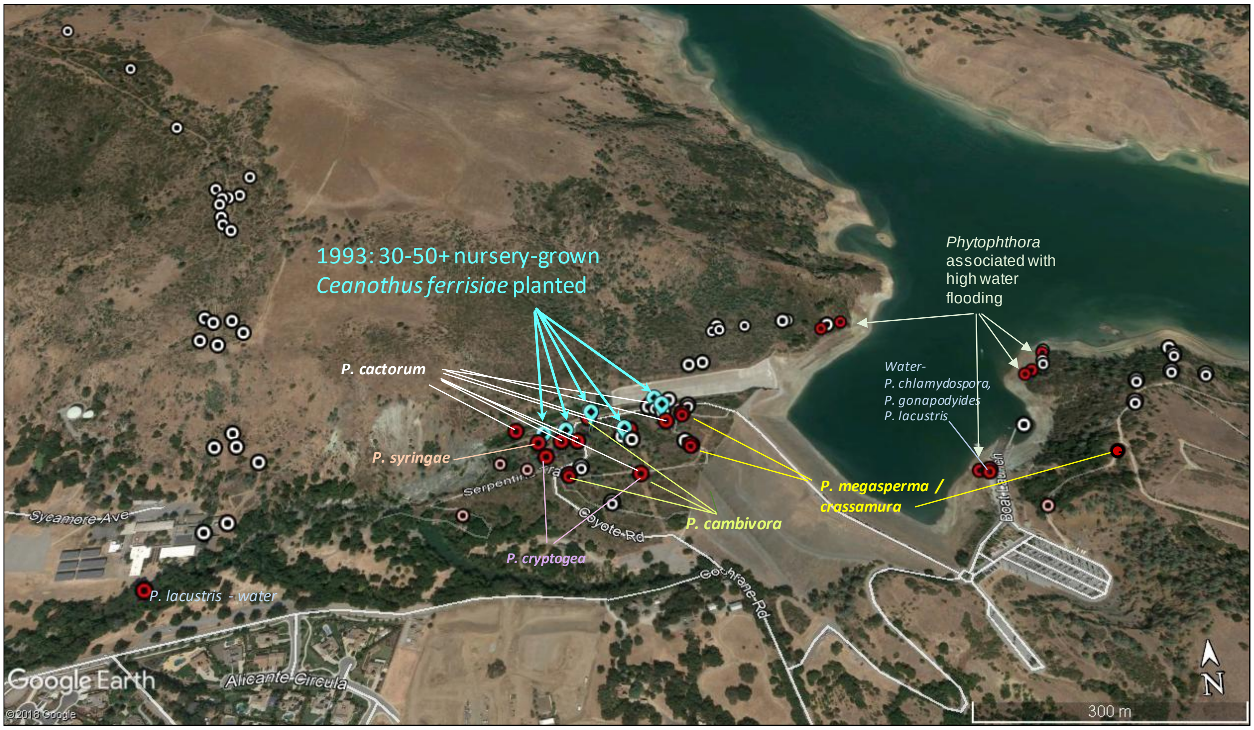

Figure 3.2.1-6. Results for all sampling in the Anderson Lake *Ceanothus ferrisiae* population areas, 2015-2018. The Coyote Ridge stand sample points are on the left side of image. White round icons are negative sample locations, red icons mark *Phytophthora* detections.

Table 3.2.1-1. Samples collected near Anderson Lake in the Anderson Dam *Ceanothus ferrisiae* population on 17 March; 18 and 27 December 2017; and 17 January 2018. Sequencing details are shown in Table 3.2.1-2.

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR170317 -AD23	water	Anderson Lake, left side boat launch among dead underwater *Baccharis* due to unusually high water levels in the lake. At the highest levels during recent storms the *Baccharis* would have been 2m below surface. Water temp 66F. Water depth where subsamples collected about 30cm, 5 subsamples, water turbid, tiny bits of debris.	*Phytophthora chlamydospora, P. gonapodyides*, and *P. lacustris* complex
PR170317 -AD24	*Ceanothus ferrisiae*	West side of Lake View trail, about 20 m long patch of large CEFE plants with some dieback, but mostly look good. Dead *Pinus sabiniana* on each side of the CEFE. Sample root density-low/moderate; soil moist, about field capacity, very sticky; soil temp 61F at 10 cm depth. Four subsamples.	no *Phytophthora*
PR170317 -AD25	*Heteromeles arbutifolia*	Along north side of Lake View trail, toyon with dieback, especially on the north side of plant. *Arctostaphylos* looks ok on E side of plant, but several other thinnish toyons. Sample AD24 CEFE is about 10 m away. Perhaps an old dead *Pinus sabiniana* has failed on 1 side, as there is some soil disturbance. Sample root density-high; soil moist, less than field capacity, sticky, O horizon/duff very deep, about 7 cm. Three subsamples.	no *Phytophthora*
PR170317 -AD26	*Frangula californica*	Downslope and north of Lake View trail, 3 to 4 dead coffeeberry in a row. At end of row a live coffeeberry, and at the other end a declining coffeeberry. Sample root density-moderate; soil moist, less than field capacity, clayey, sticky, organic top layer. Three subsamples.	no *Phytophthora*
PR170317 -AD28	*Heteromeles arbutifolia*	Downslope and north of Lake View trail, a larger dead toyon and a healthy small toyon growing intertwined. Sample root density-moderate; soil moist, less than field capacity, clayey, good structure. Two subsamples, probably some poison oak roots.	no *Phytophthora*
PR170317 -AD29	*Ceanothus ferrisiae*	Above and east of Lake View trail on west edge of meadow along social trail. Older plants decadent, with lots of dieback, younger plants look good, also an old dead *Arctostaphylos* in this decadent clump of plants. Sample root density-moderate; soil moist, less than field capacity, clayey, good structure. Five subsamples.	no *Phytophthora*
PR170317 -AD30	*Frangula californica, Heteromeles arbutifolia*	On dam abutment, about 20m downslope of Serpentine trail to south. Coffeeberry and toyon with dieback, small leaves, toyon leaves reddening; old dead *Arctostaphylos*, sage on slopes looks ok, dieback in neighboring BAPI, *Mimulus aurantiacus* of variable appearance. In small level area. Sample root density -high; soil- moist, less than field capacity, not sticky, loam or clay loam. Soil temp @10cm=57F. 4 subsamples, 2 toyons and 2 coffeeberries.	*Phytophthora cambivora*
PR170317 -AD31	*Heteromeles arbutifolia*	On dam abutment, along Serpentine trail. Toyon with dieback and dead scaffolds. Nearby California sagebrush and *Mimulus aurantiacus* look ok. Sample root density-high; soil moist, less than field capacity, gravelly, not sticky. Four subsamples from two toyons.	no *Phytophthora*
PR170317 -AD32	*Artemisia californica, Solanum sp.*	On dam abutment along Serpentine trail. Area with many dead and declining *Artemisia californica*, wilting *Solanum* sp., probably *S. umbelliferum*. Nearby *Baccharis* looks good. Sample root density-high; soil dry upper cm of soil profile, less than field capacity at greater depth, clayey. Four subsamples.	*Phytophthora crassamura*
PR170317 -AD33	*Artemisia californica*	On dam abutment along terrace to east of Serpentine trail. Area with many dead and declining *Artemisia californica*. Sample root density-high; soil- moisture less than field capacity	*Phytophthora crassamura*

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR170317-AD34	*Ceanothus ferrisiae*	Older bigger plant with dieback, downslope from Serpentine trail. Adjacent *Artemisia californica* and poison oak look good. *Eriodictyon* looks good, but adjacent medium size toyon is dead. Sample root density-high, soil-moisture less than field capacity, clay loam, not sticky, four subsamples.	no *Phytophthora*
PR170317-AD35	*Baccharis pilularis, Frangula californica*	On dam abutment near bottom of slope. Level area, with occasional dieback on *Baccharis*. Dead coffeeberry on bank above level area for one subsample. *Artemisia californica* and *Mimulus aurantiacus* look ok, as does sage. Sample root density-high; soil- moisture slightly moist. Four subsamples.	no *Phytophthora*
PR171218-AD36	*Ceanothus ferrisiae,* grass	Reservoir south shore NE of boat launch just above high-water line. CEFE with varying amount of canopy dieback - up to 50%. Sample root density: moderate, but few CEFE roots. Soil: loam, moist, soil temperature 43 F. 3 subsamples.	no *Phytophthora*
PR171218-AD37	*Ceanothus ferrisiae*	Reservoir south shore NE of boat launch below high-water line. Three small <0.5 m tall dead CEFE with attached leaves that had recruited below the high-water line and were inundated during winter 2017, in bare soil.	*Phytophthora asparagi, P.* taxon agrifolia
PR171218-AD38	*Ceanothus ferrisiae*	Reservoir south shore NE of boat launch at edge of high-water line. CEFE with <50% canopy dieback, some samples collected from the upslope side of the plants. Sample root density: moderate. Soil: loam, moist, soil temperature 46 F. 4 subsamples.	no *Phytophthora*
PR171218-AD39	*Ceanothus ferrisiae, Arctostaphylos glauca, Heteromeles arbutifolia*	Reservoir south shore NE of boat launch, on slope 15-20 ft above high-water line. CEFE look good, ARGL look good, toyon with high dieback. Sample root density: high. Soil: loam, moist, soil temperature 44 F. 5 subsamples.	no *Phytophthora*
PR171227-AD40	*Ceanothus ferrisiae, Arctostaphylos glauca*	Reservoir south shore NE of boat launch. Small <1 m tall dead plants inundated by high water, elevation 626 ft. Soil: moist rocky sandy loam, green serpentine rock, west edge of CEFE stand. Sample root density: high. 4 subsamples.	*Phytophthora crassamura, P. chlamydospora*
PR171227-AD41	*Ceanothus ferrisiae*	Reservoir south shore NE of boat launch. Small <1 m tall dead plants below eroded bank at high water level. Soil: moist rocky clay loam, sticky, Sample root density: moderate. Soil temperature 40F. 5 subsamples.	*Phytophthora megasperma* complex*, P. gonapodyides*
PR171227-AD42	*Baccharis pilularis*	Reservoir south shore directly N of boat launch. Dead large BAPI that would have been inundated by high water in 2017, north side boat landing. Soil: slightly moist loam, not sticky, geotextile fabric by the uppermost BAPI; could this be a planted array? Uniform sized BAPI. Sample root density: moderate. Soil temperature 44F. 4 subsamples.	*Phytophthora crassamura*
PR171227-AD43	*Ceanothus ferrisiae, Artemisia californica, grass*	South facing slope N of spillway. Along social trail, mostly good-looking chaparral with some scattered older dead CEFE (plants defoliated) presumably dating to 2014/2015 or earlier based on TS visit in 2015. Sample root density: moderate. Soil temperature 55F, slightly moist light sandy loam. 3 subsamples.	no *Phytophthora*
PR171227-AD44	*Ceanothus ferrisiae, Artemisia californica, grass*	South facing slope N of spillway. Healthy CEFE with some recent flagged branches on upper side of open area along trail. Healthy CEFE + chaparral downslope but upslope a few dead defoliated smaller CEFE. Sample root density: moderate. Soil temperature 60F, light sandy loam. 3 subsamples.	no *Phytophthora*

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR171227-AD45	*Ceanothus ferrisiae, Artemisia californica, Eriophyllum?*	South facing slope N of spillway. An area with poor CEFE growth in a network of social trails. Sampled 3 CEFE with poor growth, chlorosis, and recent dieback, stunted relative to other CEFE nearby. Sample root density: high. Soil temperature 61F, dry light loam. 3 subsamples.	no *Phytophthora*
PR171227-AD46	*Ceanothus ferrisiae, Artemisia californica,* grass	South facing slope N of spillway in mostly level area where CEFE are mostly large and healthy. A few short old dead CEFE in two spots but mostly the chaparral looks good, a few flags in the CEFE here and there. Sample root density: high. Soil temperature 48F, slightly moist clay loam, slightly sticky. 3 subsamples.	no *Phytophthora*
PR171227-AD47	*Ceanothus ferrisiae*	Reservoir north shore E of spillway Three dead and 1 live plant, all with roots below the high-water line. Sample root density: moderate. Soil temperature 51F, moist clay loam. 3 subsamples.	*Phytophthora gonapodyides, P. crassamura*
PR171227-AD48	*Ceanothus ferrisiae, Artemisia californica*	Reservoir north shore E of spillway. Dead ARCA and CEFE with lots of canopy dieback. Right at the wrack line, dead ARCA would have been inundated. Sample root density: high. Soil temperature 56F, nearly dry clay loam. 3 subsamples.	*Phytophthora crassamura*
PR171227-AD49	*Ceanothus ferrisiae*	Transplanted CEFE in basins on dam abutment. One recent dead still with leaves and 2 with dieback, all about 2 m tall, varying degrees of spindly, think 1 was previously sampled. Toyons nearby generally look good, lowest subsample has nearby stunted toyon with dieback. Sample root density: moderate. Soil temperature 50F, dry clay loam, gravel, sample less than 10 cm depth. 3 subsamples.	no *Phytophthora*
PR171227-AD50	*Artemisia californica, Baccharis pilularis*	On dam abutment. ARCA dead and declining, *Solanum umbelliferum* dead, BAPI seems to be invading this area and replacing the ARCA and *Solanum*. Sample root density: low. Soil: temperature 54F, dry, clayey, cloddy, one subsample slightly moist. 3 subsamples.	*Phytophthora megasperma* complex
PR171227-AD51	*Ceanothus ferrisiae, Heteromeles arbutifolia*	On dam abutment. Area where large toyon has died in past, some old dead CEFE, others here look good, are large tall plants, toyon looks good but slightly wilted. Sample root density: moderate/high. Soil: temperature 55F, dry, clayey, cloddy, rocky, one subsample very slightly moist. 3 subsamples.	*Phytophthora cactorum*
PR180117-AD52	*Heteromeles arbutifolia, Artemisia californica*	Alongside west side of Lake View trail just above Anderson Lake parking lot. Toyon slightly stressed looking but big berry crop. Additional toyon to west at edge steep slope has chlorosis, thinning, top dieback on west side of plant. Sample root density: high. Soil: moist, rocky loam. Soil temperature 63 F. 3 subsamples.	no *Phytophthora*
PR180117-AD53	*Heteromeles arbutifolia, Artemisia californica, Baccharis pilularis*	Level area inner side of broad curve of Lake View trail and below crossing trail, possibly ponding hear during storms. Sampled BAPI with severe dieback, ARCA with significant dieback, toyon with scattered dieback, some chlorosis, small leaves. Sample root density: high. Soil: moist, near field capacity, clayey, sticky. Soil temperature 53 F. 4 subsamples.	*Phytophthora crassamura*
PR180117-AD54	*Sambucus nigra* ssp. *caerulea, Ceanothus ferrisiae, Heteromeles arbutifolia, Baccharis pilularis, Salvia mellifera*	Along Serpentine Trail. CEFE tall but thin, dieback in lower canopy branches, SAME looks good, strong watersprouts from base, toyon with dieback, low vigor, old dead and declining BAPI adjacent, *Salvia mellifera* looks ok, as does flowering *Grossularia*. Sample root density: moderate/high. Soil: moist clay loam. Soil temperature 57 F. 4 subsamples.	no *Phytophthora*

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR180117-AD55	*Heteromeles arbutifolia, Artemisia californica, Baccharis pilularis, Diplacus aurantiacus*	Along social trail off Serpentine Trail. Dieback and stunting of BAPI, toyon stunting and chlorosis, big berry crop. CEFE upslope look ok and are flowering. *Salvia mellifera* and ARCA look ok, DIAU ok, not great. Sample root density: high. Soil: moist, clayey to sandy clay loam. Soil temperature 56 F. 4 subsamples.	no *Phytophthora*
PR180117-AD56	*Frangula californica, Sambucus nigra* ssp. *caerulea*	At low spot of trail junction where Serpentine Trail starts uphill from near picnic area. SAME large but decadent, FRCA also large, tall, but some dieback and thinning, is multistemmed, DBH of stems about 6 cm. Sample root density: high. Soil: moist, sandy to rocky, clayey to sandy clay loam. Soil temperature 56 F. 4 subsamples.	no *Phytophthora*

Table 3.2.1-2. DNA sequencing details for *Phytophthora* isolates recovered during 17 March 2017 sampling of the Anderson Lake population of *Ceanothus ferrisiae*

Isolate number	PDR number	Identification	Sequencing result details
PR170317-AD23-1	MV6P06578742-1	*Phytophthora chlamydospora*	*Phytophthora chlamydospora ITS: 99% (822/824)*
PR170317-AD23-2	MV6P06578742-2	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: 100% (812/812)
PR170317-AD23-3	MV6P06578742-3	*Phytophthora lacustris* complex	*Phytophthora lacustris complex* ITS: 99% (808/810)
PR170317-AD30	MV6P06578743-1	*Phytophthora cambivora*	*Phytophthora cambivora* ITS: 100% (813/813)
PR170317-AD32-5	MV6P06578743-2	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: 100% (813/813)
PR170317-AD33-1	MV6P06578743-3	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: 100% (810/810)
PR170317-AD33-2	MV6P06578743-4	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: 100% (810/810)
PR171218-AD37-4	MV6P06578765-1	*Phytophthora asparagi*	*Phytophthora asparagi* ITS: GenBank (813/813) PhytID (813/813)
PR171218-AD37-9	MV6P06578764-2	*Phytophthora* taxon agrifolia	*Phytophthora* taxon agrifolia ITS: *Phytophthora foliorum* GenBank (755/814). 100% match to previously isolated species from San Mateo county.
PR171227-AD40-1	MV6P06578767-2	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: GenBank (806/806) PhytID (806/806)
PR171227-AD40-5	MV6P06578767-3	*Phytophthora chlamydospora*	*Phytophthora chlamydospora* ITS: GenBank (827/827) PhytID (811/812)
PR171227-AD40-9	MV6P06578767-4	*Phytophthora chlamydospora*	*Phytophthora chlamydospora* ITS: GenBank (828/828) PhytID (814/814)
PR171227-AD41-1	MV6P06578767-5	*Phytophthora megasperma*	*Phytophthora megasperma* ITS: GenBank (824/827) PhytID (804/807), to ex-type sequence HQ643275; 821/826 to KU053273 from roots *Abies procera* (noble fir) Xmas tree farm WA state
PR171227-AD41-3	MV6P06578768-1	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: GenBank (827/827) PhytID (819/819)
PR171227-AD42-1	MV6P06578768-2	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: GenBank (807/807) PhytID (807/807)
PR171227-AD47-6	MV6P06578768-3	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: GenBank (835/835) PhytID (815/815)
PR171227-AD47-7	MV6P06578768-4	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: GenBank (807/807) PhytID (807/807)
PR171227-AD48-2	MV6P06578768-5	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: GenBank (806/806) PhytID (756/756)
PR171227-AD48-5	MV6P06578769-1	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: GenBank (813/813) PhytID (806/806)
PR171227-AD50-4	MV6P06578769-2	*Phytophthora megasperma*	*Phytophthora megasperma* ITS: GenBank (815/818) PhytID (803/806) to KU053273 from roots *Abies procera* (noble fir) Xmas tree farm WA state. 815/820 to ex-type sequence HQ643275 *two ambiguous nucleotides
PR171227-AD51-2	MV6P06578769-3	*Phytophthora cactorum*	*Phytophthora cactorum* ITS: GenBank (808/808) PhytID (786/787)
PR180117-AD53-1	MV6P06578772-4	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: GenBank (819/819) PhytID (756/756)

Table 3.2.1-3. Samples collected near the PG&E pipeline route in the Coyote Ridge *Ceanothus ferrisiae* stand.

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR161104-PGE01	*Arctostaphylos glauca, Ceanothus ferrisiae*	Plants look very healthy. Some of the largest plants are over 1.75m tall. Some of these have dieback of the upper stems. Four subsamples. Root density in sample moderate/high, soil moist, slightly less than field capacity, but sticky. Samples no more than 20 cm deep	no *Phytophthora*
PR161104-PGE02	*Arctostaphylos glauca, Ceanothus ferrisiae, Heteromeles arbutifolia*	Lots of stem dieback in this area, dieback of upper shoots. Four subsamples. Root density in sample moderate, soil moist, less than field capacity, but sticky. Samples no more than 20 cm deep.	no *Phytophthora*
PR161104-PGE03	*Arctostaphylos glauca, Ceanothus ferrisiae, Heteromeles arbutifolia*	Dead plants, some with dieback, no *Botryosphaeria* lesions seen, dieback seems to be due to drought, no cankers seen. Four subsamples. Root density in sample low/moderate, soil moist, slightly less than field capacity, but sticky. Samples no more than 20 cm deep. Soil temp 63F to 60.5F	no *Phytophthora*
PR161104-PGE04	*Pinus sabiniana, Ceanothus ferrisiae, Heteromeles arbutifolia*	Plants from OK to dead, on W side of ravine East of road. Four subsamples. Root density low, soil light and drier than previous samples.	no *Phytophthora*
PR161104-PGE05	*Arctostaphylos glauca, Ceanothus ferrisiae*	Dead and declining plants, samples shallow, at most 18 cm. 6 subsamples. Root density in sample low, soil < field capacity, slightly sticky.	no *Phytophthora*
PR161104-PGE06	*Arctostaphylos glauca, Ceanothus ferrisiae*	Area of short plants, a number are dead, impacted by the original pipeline construction? hard to find roots, 5 subsamples, sample root density low, soil reddish brown, sticky, < field capacity.	no *Phytophthora*
PR161104-PGE07	*Ceanothus ferrisiae*	Area of short plants, some dead and newly dead, hard to find roots, 4 subsamples, sample root density low, soil gritty, < field capacity, sticky.	no *Phytophthora*
PR161104-PGE08	*Ceanothus ferrisiae*	Plants short 0.5-1 m tall, some small plants are dead, sample root density moderate to low, soil moist, < field capacity, gritty, and sticky.	no *Phytophthora*

3.2.2. Kirby Canyon population

We sampled the Kirby Canyon population of *Ceanothus ferrisiae* on 24 October 2016 with Janell Hillman. We returned to this area and sampled entryways to the population on 17 January 2018. Data for all sampling is shown in Figure 3.2.3-1 and Tables 3.2.3-1 and 3.2.3-2. No *Phytophthora* species were detected in root/soil samples collected on October 2016 or January 2018. These included October 2016 samples collected within the *C. ferrisiae* stand and January 2018 samples collected along foot trails at the base of the slope that are used to access the stand. However, *Phytophthora* species were detected in water samples collected on both dates.

In initial sampling in October 2016, two *Phytophthora* isolates were detected in a single water sample collected from the stream flowing through the ravine at the base of the drainage that cuts through this population. One isolate was identified as *Phytophthora lacustris* complex. The other isolate did not match well to any known described species (Table 3.2.3-2). The nearest ITS match was to *Phytophthora* taxon "forestsoil-like", an undescribed species that was isolated from two Taiwan rivers by Jung et al (2016). Our isolate was one base pair different from that isolate (Table 3.2.3-2). Jung et al (2016) did not submit a COX2 gene sequence for this isolate to GenBank, hence the poor matches to known species for the COX2 gene shown in Table 3.2.3-2.

We collected two water samples in January 2018 at points downstream from the initial Oct 2016 water detection. *P*. taxon “forestsoil-like” was detected in both downstream samples. Strains in the *P. lacustris* complex were also detected (Figure 3.2.3-1 and Tables 3.2.3-1 and 3.2.3-2). An additional species, *P. acerina*, was also detected in the furthest downstream sampling point (K16, Figure 3.2.3-1). Unlike the other two clade 6 species, *P. acerina* is a recently described terrestrial species in the *P. citricola* group (clade 2c), a well-known group of root-rot pathogens. The implication of this find is that this soil-borne species appears to be associated with woody vegetation at the base of the ravine. Because this area is used as a point of entry to the upslope *C. ferrisiae* population, users of this area could inadvertently spread this pathogen upslope unless they follow proper phytosanitary procedures to clean contaminated footwear or tools. The potential pathogenicity of *P. acerina* to native species in this area is unknown.

We also collected water from two large puddles along an unsurfaced road that eventually leads to the base of Kirby canyon. These puddles are filled only by rainfall and are large enough that vehicles traveling on the road would likely drive through them. *Phytophthora gonapodyides* was detected in both puddles. (Figure 3.2.2-1, Table 3.2.2-2). The presence of *P. gonapodyides* in the puddles emphasizes the known ability of this species to be moved between wet sites. This species was also detected in a sample from the seasonal creek flowing out of Kirby Canyon.

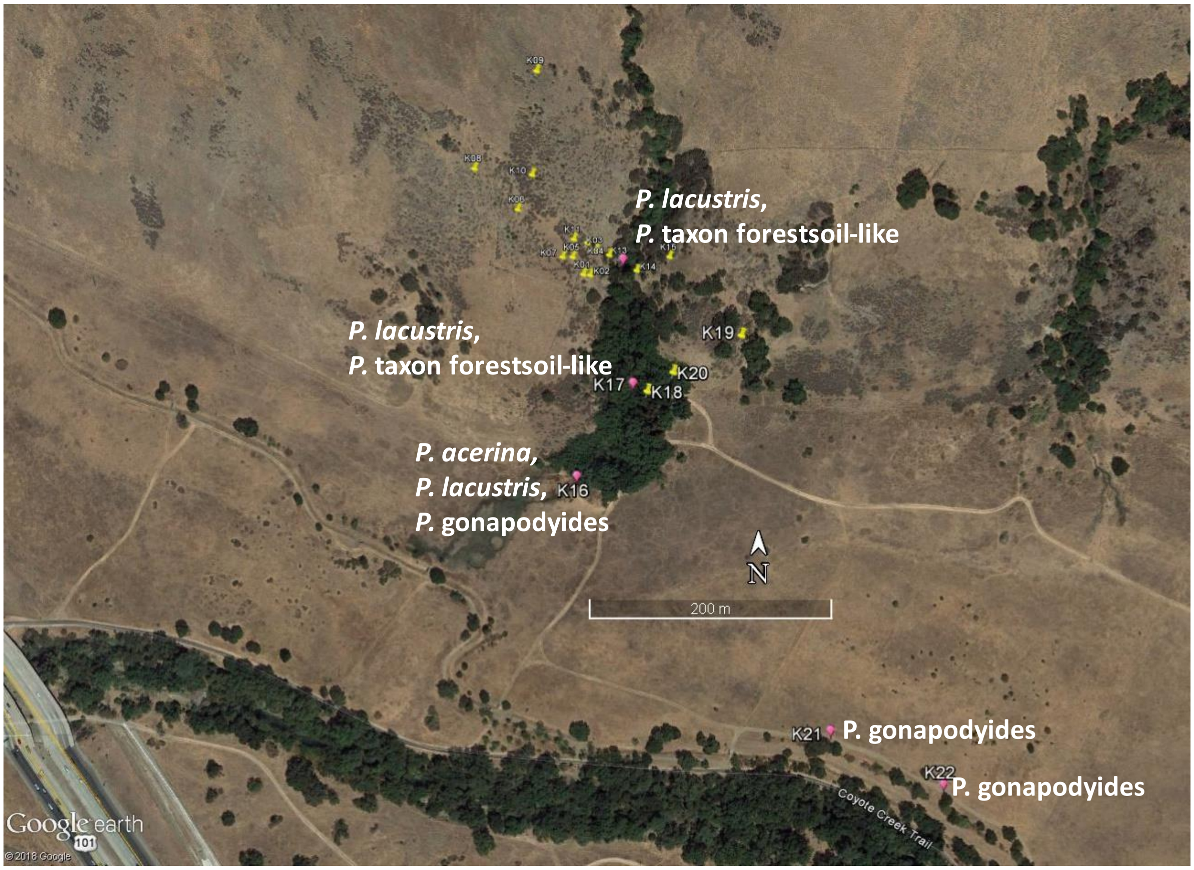

Figure 3.2.2-1. Points in and near the *Ceanothus ferrisiae* stand at Kirby Canyon sampled on 24 October 2016 and 17 January 2018. Pink icons indicate a *Phytophthora* isolate was detected from the sample, yellow icons indicate negative samples. Inverted-drop icons represent water samples. Sample details are in Tables 3.2.3-1 and 3.2.3-2.

Table 3.2.2-1. Samples collected from Kirby Canyon *Ceanothus ferrisiae* population area on 24 October 2016 and 17 January 2018.

Sample number	Vegetation sampled	Notes	*Phytophthora* species detected
PR161024-K01	*Ceanothus ferrisiae*	W of ravine, E of fence. Area of dead and declining CEFE. Dug to 30 cm depth, but hardly any roots. Large dead/declining plant. Root density very low, soil moist/light, loamy, <field capacity. 6 subsamples.	no *Phytophthora*
PR161024-K02	*Scrophularia californica*	W of ravine, E of fence. Severely died back but resprouting, just down slope from K01. 2 subsamples, root density low, soil moist, < field capacity, light loam.	no *Phytophthora*
PR161024-K03	*Ceanothus ferrisiae*	W of ravine, E of fence. Dieback of larger plants, a few 1 cm diam roots but few fine roots, root density very low, 4 subsamples; soil light, loamy, moist, < field capacity.	no *Phytophthora*
PR161024-K04	*Arctostaphylos glauca*	W of ravine, E of fence. Very large plant with dieback, only fine roots (grass) in sample, root density very low, 3 subsamples, soil light, loamy, moist, < field capacity	no *Phytophthora*
PR161024-K05	*Ceanothus ferrisiae, Artemisia californica*	In fenced area W of ravine. Shrubby transplant, hardware cloth basket around base, browning of shoots due to rodent debarking, 5 subsamples, root density moderate, soil clay loam, moist, < field capacity	no *Phytophthora*
PR161024-K06	*Ceanothus ferrisiae*	In fenced area W of ravine. Dead plant, looked rooted but rotted at the root crown, no roots, soil moist, clay loam, < field capacity.	no *Phytophthora*
PR161024-K07	Wire basket, no plant	In fenced area W of ravine. Sampled where wire basket found, also flagging tape unearthed, no roots left, no nursery mix seen, soil moist, clay loam	no *Phytophthora*
PR161024-K08	*Ceanothus ferrisiae*	W (upslope) of fenced area. Above fence. 2 plants that mostly look ok, 1 dead plant, 6 subsamples, root density low, soil moist, light, < field capacity	no *Phytophthora*
PR161024-K09	*Ceanothus ferrisiae*	W (upslope) of fenced area. Eastern high sample point, plants mostly look pretty good, 3 healthy plants on rocky ridge, within 1-3 m are dead and declining plants, 6 subsamples, mod/high root density, soil moist, rocky, sandy, < field capacity.	no *Phytophthora*
PR161024-K10	*Ceanothus ferrisiae, Artemisia californica*	In fenced area W of ravine. Healthy plants, upper E side of ravine, 4 subsamples from 3 plants, root density mod/high, soil moist, loamy, light, not very rocky, < field capacity	no *Phytophthora*
PR161024-K11	*Ceanothus ferrisiae*	In fenced area W of ravine. Large dead plant, used in genetic test study. Janell remembers as prolific reseeder. Root density low, 6 subsamples, soil light, loamy, moist, < field capacity	no *Phytophthora*
PR161024-K12	*Heteromeles arbutifolia, Artemisia californica*	In fenced area W of ravine. Small toyon with stem chewed by mice under large sagebrush in swale by fence. 1 area sampled, root density low, soil light, loamy, moist, < field capacity.	no *Phytophthora*
PR161024-K13	water	Flowing water in creek. From small creek that drains ravine, streamside vegetation includes *Stachys, Umbellularia californica, Rubus*, stinging nettle, poison oak, coffeeberry, toyon, *Q. agrifolia*.	*Phytophthora lacustris* complex, *P*. taxon “forestsoil-like”
PR161024-K14	*Ceanothus ferrisiae*	East of creek on west facing slope, 4 healthy plants and 4 subsamples, root density moderate, soil moist, sticky clay loam, < field capacity.	no *Phytophthora*
PR161024-K15	*Ceanothus ferrisiae*	East of creek on upper part of west facing slope, 2 healthy plants, 1 with dieback on top, and 4 subsamples, root density high, soil moist, sticky clay loam, < field capacity.	no *Phytophthora*

Sample number	Vegetation sampled	Notes	*Phytophthora* species detected
PR180117-K16	water	Sampled small channel where water flowed out of *Ailanthus/Acacia* grove at bottom of ravine into field. Water flow rate moderate/low, channel about 0.4 m wide, 4 cm deep, flows through *Acacia* (*baileyana*?), dock, poison hemlock. Water temperature 56 F, 5 subsamples.	*Phytophthora acerina, P. lacustris* complex, *P. gonapodyides*
PR180117-K17	water	Main channel for ravine drainage, in Ailanthus, but no veg in channel, mineral bottom. Upstream are *Ailanthus, Eucalyptus globulus, Quercus agrifolia, Pinus* sp. Water flow rate moderate/high, channel about 0.4 m wide, 4 cm deep. Water temperature 56 F, 5 subsamples.	*Phytophthora lacustris* complex, *P*. taxon “forestsoil-like”
PR180117-K18	*Ailanthus, Acacia melanoxylon*	DBH of Acacia 20-30 cm, a few small dead saplings in understory, tops look ok, right before trail ends at drainage. UC Santa Cruz study ongoing at time of sample collection with equipment (cage) nearby. Sample root density: high. Soil: moist, clay loam. Soil temperature 56 F. 3 subsamples.	no *Phytophthora*
PR180117-K19	*Quercus agrifolia, Artemisia californica*	On lower slope, healthy looking QUAG saplings at canopy edge of large QUAG and adjacent ARCA chaparral. ARCA cluster of dead plants, also areas ARCA with dieback. Lots of shallow roots in upper 15 cm of soil profile. Sample root density: high. Soil: moist, sticky, clay loam. Soil temperature 62 F. 4 subsamples.	no *Phytophthora*
PR180117-K20	*Quercus agrifolia, Umbellularia californica, Ailanthus*	Large QUAG about 1 m DBH in swale at toe of slope, looks ok, bushy UMCA seedlings <1 m tall. By social trail that ascends hill. Lots of roots in upper 15 cm soil profile. Sample root density: high. Soil: moist, clay loam. Soil temperature 57 F. 4 subsamples.	no *Phytophthora*
PR180117-K21	water	Puddle across road under canopy of QUAG that looks fine. Puddle 4 x 5 m, probably max depth about 10 cm, sampled surface where puddle was ~4 cm deep, bottom muddy, grass blades to about 1 cm just emerging at edges puddle, also QUAG leaves in puddle. Water clear, temperature 56F, 5 subsamples.	*Phytophthora gonapodyides*
PR180117-K22	water	Puddle across road, surrounded by annual vegetation and grass, most dead or dormant. A few QUAG leaves in water, but not under canopy. Puddle 6 x 3 m, probably max depth about 10 cm, sampled surface where puddle was ~4 cm deep, bottom muddy. Water turbid, temperature 62 F, 5 subsamples.	*Phytophthora, gonapodyides*

Table 3.2.2-2. DNA sequencing details for *Phytophthora* isolates from the area of the Kirby Canyon *Ceanothus ferrisiae* population.

Isolate number	PDR number	Identification	Sequencing result details
PR161024-K13.1	MV6P0657810	*Phytophthora lacustris* complex	*Phytophthora lacustris* ITS: 100% (600/600) One direction only; *Phytophthora lacustris* COX2: 100% (527/527)
PR161024-K13.2	MV6P0657811	*Phytophthora* taxon “forestsoil-like”	*Phytophthora* taxon "forestsoil-like" ITS: 808/809 to KU6882574
PR180117-K16-2	MV6P06578772-1	*Phytophthora acerina*	*Phytophthora acerina* ITS : GenBank *P. acerina* (777/778) to isolate TARI 23044, due to known polymorphism described in species description
PR180117-K16-4	MV6P06578772-2	*Phytophthora lacustris* complex	*Phytophthora lacustris* ITS: to type JQ626605.1 619/620
PR180117-K16-5	MV6P06578772-3	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: GenBank (825/825) PhytID (762/762)
PR180117-K17-1	MV6P06578773-1	*Phytophthora lacustris* complex	*Phytophthora lacustris*, GenBank (819/819),PhytID (756/756); ITS: to type JQ626605.1 99% (638/641)

Isolate number	PDR number	Identification	Sequencing result details
PR180117-K17-2	MV6P06578773-2	*Phytophthora* taxon “forestsoil-like”	*Phytophthora* taxon "forestsoil-like" ITS: GenBank (813/814) to KU6882574 100% match to PR161024-K13-2
PR180117-K21-7	MV6P06578773-3	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: GenBank (824/825), PhytID (761/762) * Off by 1bp that is C/T (Y)
PR180117-K21-8	MV6P06578773-4	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: GenBank (826/826,) PhytID (762/762)
PR180117-K22	MV6P0657874	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: GenBank (799/801) PhytID (742/743) ex-type KF112854.1 790/793(99%)

3.2.3. Llagas population

Janell Hillman obtained permission for us to visit and sample the eastern part of the *C. ferrisiae* population from the property owner and we visited the site with her 26 October 2016. We collected 10 samples. All but one sample were in upland *C. ferrisiae* habitat; one sample was collected in muddy soil around the edge of a dammed, spring-fed pond used as a water source by cattle (LL06).

Of the 10 samples collected from this population (Table 3.2.3-1, Figure 3.2.3-1), only the sample collected from saturated soil at the edges of the pond (PR161026-LL06) yielded a *Phytophthora* species. This isolate appears to possibly be a hybrid between *P. inundata* and *P. humicola* (Table 3.2.3-2). It is similar to PR160817-CP13.7, which was baited from saturated soil at the edge of one of the ponds in the north portion of Calero County Park (section 3.3.2; see also description of *Phytophthora inundata* in section 6).

Janell Hillman and SCVHA attempted to obtain permission for sampling from the owner of the western part of the Llagas *C. ferrisiae* population. The easement held by the City of Morgan Hill forbids extraction of soil, and the landowner refused to grant permission for sampling.

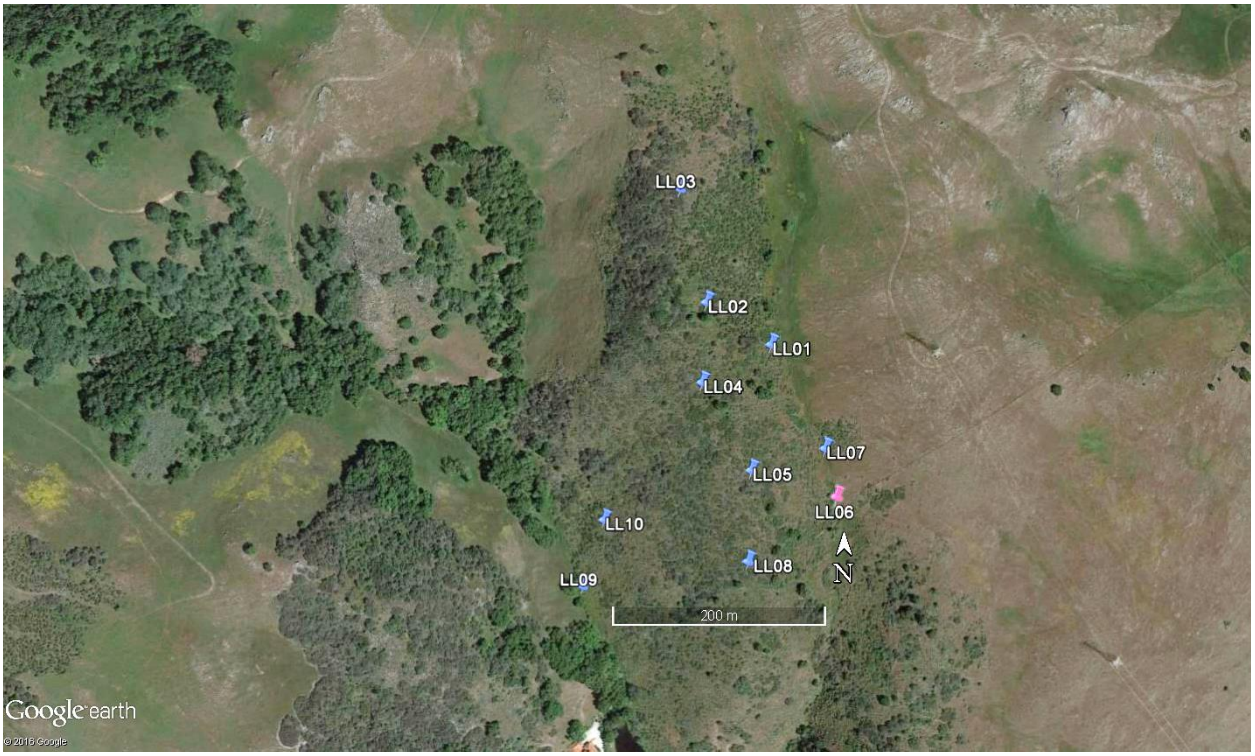

Figure 3.2.3-1. Sample locations for the Llagas population of *Ceanothus ferrisiae.* Pink icon represents a *Phytophthora inundata* strain detected in a sample from wet soil around a pond. *Phytophthora* was not detected at other sample points.

Table 3.2.3-1. Samples collected in the eastern half of the Llagas *Ceanothus ferrisiae* population.

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR161026-LL01	*Ceanothus ferrisiae*	Slightly decadent stand of old plants, dieback of upper stems, most dead plants are to E side of stand. 5 subsamples; root density low for CEFE, moderate overall, soil moist, clay loam, good tilth, fluffy.	no *Phytophthora*
PR161026-LL02	*Ceanothus ferrisiae*	Healthy plants, 5 subsamples, root density low for CEFE, moderate overall, soil moist, clay loam, good tilth, fluffy.	no *Phytophthora*
PR161026-LL03	*Ceanothus ferrisiae, Artemisia californica*	Area with old decadent, dead, and healthy plants, on the ridge, 4 subsamples, root density low/moderate, mostly CEFE, soil moist, clay loam, good tilth, fluffy.	no *Phytophthora*
PR161026-LL04	*Ceanothus ferrisiae, Artemisia californica, Heteromeles arbutifolia*	Plants with varying amounts of dieback, nearly dead to more or less decadent. 5 subsamples, soil moist, friable, dark brown.	no *Phytophthora*
PR161026-LL05	*Ceanothus ferrisiae, Artemisia californica, Heteromeles arbutifolia*	Healthy to decadent, ridge closer to E property line fence, 4 subsamples, root density low/moderate, soil moist, friable, dark brown.	no *Phytophthora*
PR161026-LL06	*Ceanothus ferrisiae, Frangula californica, Juncus xiphioides, Paspalum distichum, Cynodon dactylon, Carex* or *Cyperus*	Spring-fed pond by east fence, heavy cattle use, healthy CEFE above, FRCA with dieback, dead CEFE at outflow of pond, 3 subsamples, root density high, soil saturated with some free water,	*Phytophthora inundata* × *humicola*
PR161026-LL07	*Ceanothus ferrisiae*	Toe of slope of little drainage, decadent plants with lots of dieback, 6 subsamples, root density low, soil moist, sticky, dark brown, noncompacted.	no *Phytophthora*
PR161026-LL08	*Ceanothus ferrisiae, Artemisia californica*	Area with decadent and healthy plants, west facing slope near E fence, 6 subsamples, root density low/moderate, soil moist, lighter textured, reddish brown.	no *Phytophthora*
PR161026-LL09	*Ceanothus ferrisiae*	Area with dead, decadent and healthy plants, at toe of west facing slope where CEFE range runs out, 6 subsamples, root density low, soil moist, sticky, friable.	no *Phytophthora*
PR161026-LL10	*Ceanothus ferrisiae, Artemisia californica*	CEFE extensive dieback, midslope of west facing slope, 4 subsamples, root density low, soil moist, lighter textured.	no *Phytophthora*

Table 3.2.3-2. DNA sequencing details for *Phytophthora* isolates from Kirby Canyon and the eastern half of the Llagas *Ceanothus ferrisiae* populations.

Isolate number	PDR number	Identification	Sequencing result details
PR161026-LL06.1	MV6P0657812	*Phytophthora inundata × humicola*	ITS: *P. inundata* 99% (803/804) to ex-type P246b GenBank AF266791.1; *P. humicola* 802/804 to ex-type 32F8=CBS 200.81 GenBank KF112855.1. COX2: *P. humicola* (543/544); *P. inundata* 540/544 [note- no COX2 sequences have been submitted for the ex-types of either *P. inundata* or *P. humicola*, complicating identification]

3.3. Field visits and sample collection in identified high-risk areas

Details of the *Phytophthora* sampling conducted in all reserve system locations other than the three *Ceanothus ferrisiae* population areas (Anderson Lake, Kirby Canyon, and Llagas) are presented in this section.

3.3.1. Almaden Quicksilver County Park

Eight root/soil samples were collected on 14 April 2017 along the Mine Hill, Day Tunnel, and Castillero trails. No *Phytophthora* was recovered from any of these samples despite the high level of past human disturbance in the area and heavily used trails. One question of interest is whether mercury residues in the soils of this area might be inhibitory to *Phytophthora*.

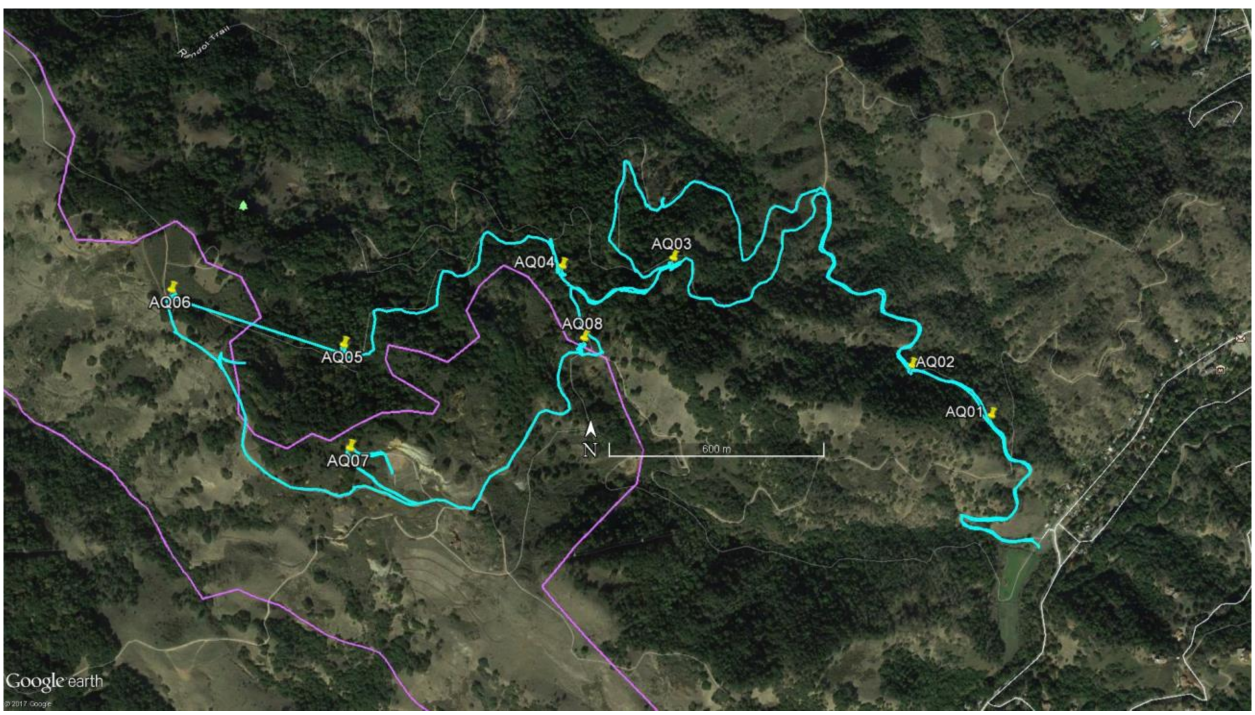

Figure 3.3.1-1. Samples collected at Almaden Quicksilver County Park on 14 April 2017. Yellow icons represent sample points; no *Phytophthora* was detected in any of the samples. Blue line represents our track. Purple line represents reserve boundary. Sample details and identifications are shown in Table 3.3.1-1.

Table 3.3.1-1. Samples collected at Almaden Quicksilver County Park 10 April 2017 in mixed serpentine chaparral, mixed oak woodland and forest, mixed evergreen forest, and coastal scrub habitats.

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR170414-AQ01	*Heteromeles arbutifolia, Baccharis pilularis, Ceanothus cuneatus*	Along Mine Hill trail, upslope from road above ditch on north-facing slope of presumably mine spoils, high shrub density surrounded by forest of large coast live and California black oaks. *Baccharis* shows some dieback, toyon with leaf tip burn. Sample root density moderate, soil moist, barely sticky, clay loam. 3 subsamples	no *Phytophthora*
PR170414-AQ02	*Mimulus aurantiacus, Artemisia californica, Artemisia douglasiana*	Background sample along Mine Hill trail, inner curve of bend in road, along small drainage ditch, slightly upslope from road on north-facing slope of presumably mine spoils. Sample root density-moderate, soil moist, barely sticky, light, stony, reddish clay loam. 4 subsamples. Soil temperature 53F at 8cm.	no *Phytophthora*
PR170414-AQ03	*Acer macrophyllum*	Along Mine Hill and Day Tunnel trails, grove of big leaf maples. Diameters mostly less than 20cm among those dead, or have significant canopy thinning and dieback. *Armillaria* mycelium seen on one root of failed tree. Longer dead two-trunked tree with diameters of 25 and 35, both with bole failures. Possibly drought related symptoms. Sample root density high, soil moist, rocky clay loam. 4 subsamples.	no *Phytophthora*
PR170414-AQ04	*Toxicodendron diversilobum, Acer macrophyllum, Baccharis pilularis, Vinca minor*	Highly disturbed area along Mine Hill trail, *Eucalyptus globulus*, and dense stand of periwinkle above trail. Below trail and downslope is a dead maple, and fading maple, dead coast live oak, dead toyon. In close proximity are healthy of same species. Poison oak and *Baccharis* look good. Sample root density moderate, soil moist, gravelly clay loam. 4 subsamples.	no *Phytophthora*
PR170414-AQ05	*Arbutus menziesii*	A pad, perhaps associated with mine spoils. First madrone seen along Mine Hill trail coming from Great Eastern Trail. Madrone thin looking, especially in center of canopy, but adjacent toyon looks ok. Nearby bay have dieback, but are not on pad, are on surrounding slope. Sample root density - high, soil-moist, clay loam. 4 subsamples	no *Phytophthora*
PR170414-AQ06	*Frangula californica*	At trail junction Mine Hill and Castillero trail, also utility corridor here. Coffeeberry with various degrees of dieback, stunting in chaparral- also *Baccharis* and broom and some live oak that looks good. *Baccharis* has some dieback. Sample root density all coffeeberry - moderate/high, soil-moist, reddish brown. 4 subsamples.	no *Phytophthora*
PR170414-AQ07	*Frangula californica, Spartium junceum, Symphoricarpos*	Along access road to Mine Hill. Broom with extensive dieback, coffeeberry looks mostly good, one slightly thin and slight chlorosis. Sample root density- moderate/high, soil- wet, stony clay loam, sticky. 4 subsamples	no *Phytophthora*
PR170414-AQ08	*Hesperocyparis macrocarpa*	Old ornamental planting of Monterey cypress by English School. Sample root density- high, soil- moist, light, friable, dark brown. Soil temperature 53F at 10cm. 4 subsamples.	no *Phytophthora*

3.3.2. Calero County Park – north

We sampled in the northern portion of Calero County Park (Rancho San Vicente) and along the Almaden Calero Canal with Janell Hillman on 17 August 2016. Enrollment of this portion of Calero Park under a conservation easement is currently pending Federal, State, and local approvals. Most of these samples were collected near access roads in upland habitats, and soils were quite dry. Four samples were collected in wet soil at the edges of two spring-fed ponds used as water sources for cattle. At the time of our sampling, wetland restoration activities were planned for these ponds, but no planting had been done. One additional sample was collected 17 April 2017 at the edge of a pad used to stage construction-related equipment and materials. Sample point descriptions and results are in Tables 3.3.2.-1 and 3.3.2.-2. The distribution of sample points is shown in Figure 3.3.2.-2.

No *Phytophthora* was detected in any of the soil/root samples from dry upland sites sampled in August 2016. None of sampled vegetation showed likely symptoms of root rot, and none of these upland sites were considered to have a high risk of *Phytophthora* introduction. However, data from another study we have been conducting over the same period indicates that detection efficiency at dry upland sites such as these can be low by mid to late summer. Nonetheless, given the number of samples taken, it is likely that a widespread infestation would have been detected if it was present in the sampled area. No *Phytophthora* was detected in the sample collected from the edge of the construction pad in April 2017, which was a more optimal timing for sampling.

At each of the two pond sites sampled in August 2016, clade 6 *Phytophthora* species were detected in one of the two root/soil samples collected per pond. *Phytophthora* taxon raspberry (identified as the closely-related *P. gregata* in our original reports) was detected at both ponds. A strain of *P. inundata* (or a *P. inundata* × *P. humicola* hybrid) was also detected at one pond. Both ponds are fed directly from springs and neither is connected with an upslope watercourse. The upper pond is in an old quarried site. The ponds are adjacent to unpaved ranch roads, so contaminated vehicles could have been a route of introduction. Alternatively, the *Phytophthora* introductions into these ponds might have occurred via livestock; both ponds had evidence of heavy use by livestock. The soil at the edge of these ponds was pitted with deep cattle tracks (Figure 3.3.2.-1). *Phytophthora* contamination from another site could have been introduced via mud on hooves, etc., when cattle were trucked to the site. Movement of cattle between water sources during grazing of the site could have moved *Phytophthora* between these unconnected ponds.

Figure 3.3.2-1. *Phytophthora* taxon raspberry was recovered from a soil sample (CP15) collected from the edge of this pond. The wet, clayey soil at the edge of the pond was hummocky due to cattle, whose hooves created deep depressions in the moist, sticky soil.

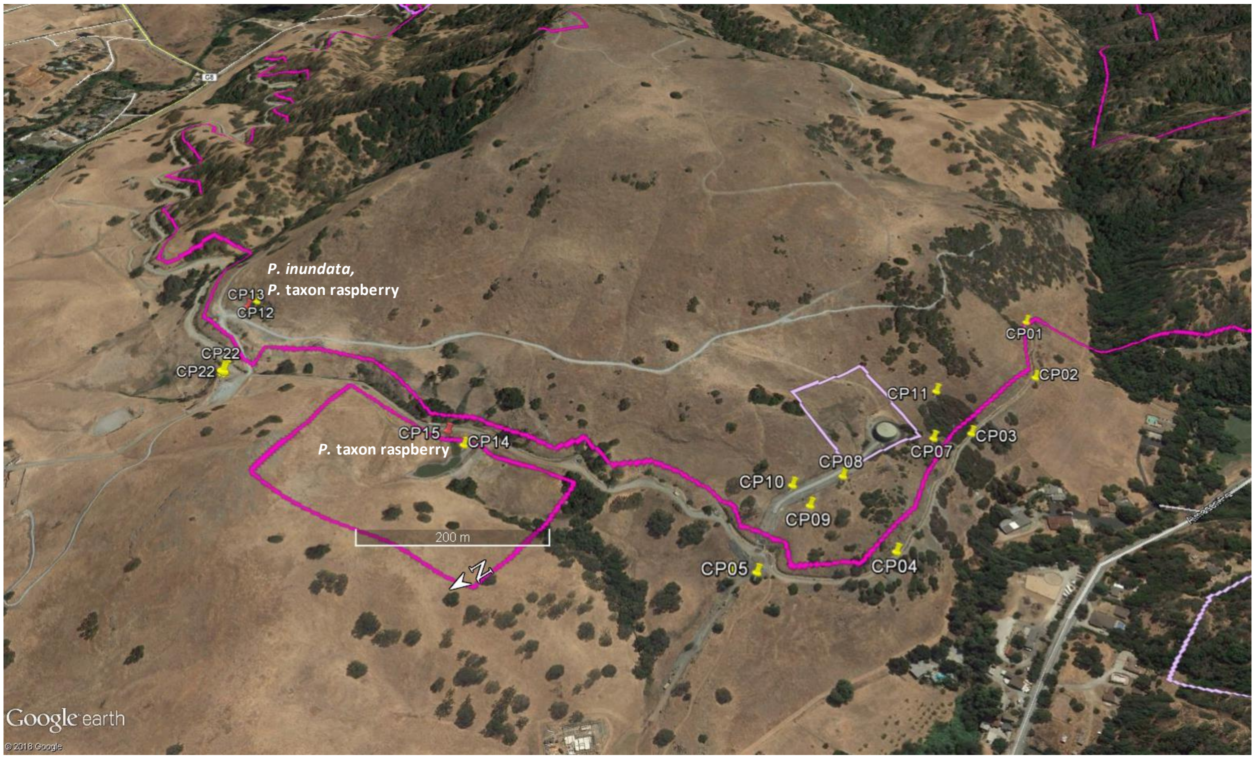

Figure 3.3.2-2. Locations of sample collected on 17 August 2016 in the north portion of Calero County Park, in and near the proposed conservation easement (magenta line). Pink icons represent sample points positive for *Phytophthora* species at two ponds.

Table 3.3.2-1. Results of sampling roots/soil of various native species for *Phytophthora* species in the north portion of Calero County Park.

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR160817-CP1	*Arctostaphylos glauca*	Root density low, soil moisture dry, plants look good and healthy, just a very few *Fusicoccum*-type dead branchlets, 3 subsamples, above canal near terminus before it goes underground.	no *Phytophthora*
PR160817-CP2	*Arctostaphylos glauca*	Root density low, soil moisture dry, a large sprawling plant with some dieback on downhill side of road next to canal, a tiny *Q agrifolia* in root zone, but roots in sample are all ARGL, 3 subsamples.	no *Phytophthora*
PR160817-CP3	*Arctostaphylos glauca*	Root density low to v. low, soil moisture dry. On west, downhill, side of road, plant looks healthy. Plants on the other side of the canal have some *Fusicoccum*-type dieback. 3 subsamples.	no *Phytophthora*
PR160817-CP4	*Arctostaphylos glauca, Quercus agrifolia, Umbellularia californica*	Root density low, soil moisture dry, downhill side of road, plants look healthy, small UMCA, and QUAG in understory of ARGL, all contributed roots to the sample. 3 subsamples.	no *Phytophthora*
PR160817-CP5	*Quercus agrifolia*	Root density moderate, soil dry, texture clay loam, but variable, downhill from bridge, under good looking tree frequented by cows. 3 subsamples.	no *Phytophthora*
PR160817-CP6	*Umbellularia californica*	Root density very high, soil moisture dry, Tree tag 960, some branch dieback, sample collected in rocky outcrop with lots of surface roots in pockets among the rocks. 3 subsamples.	no *Phytophthora*
PR160817-CP7	*Arctostaphylos glauca*	Root density high, soil moisture dry, granulated clay loam, plant a little thin with some dieback, at the top of the manzanita layer above the canal near plot corner 7076. 3 subsamples.	no *Phytophthora*
PR160817-CP8	*Frangula californica, Quercus chrysolepis*	Root density low, soil moisture dry, soil rocky, clayey, massive in areas, FRCA has thinning and dieback, oaks look ok, sample in sphere of influence of PG&E's line clearance work, tree removal, stumps have been treated with herbicide. 5 subsamples.	no *Phytophthora*
PR160817-CP9	*Stipa pulchra, Hordeum brachyantherum, Hemizonia congesta* ssp. *luzulifolia*	Root density v low and only herbaceous, soil moisture dry, soil blocky, in an area of seepage, now dry. 4 subsamples.	no *Phytophthora*
PR160817-CP10	*Frangula californica*	Root density very low, soil dry, composite of road gravel and native soil. Main trunk dead, possibly due to hack and squirt herbicide treatment, has resprouted, alongside dirt road, 4 subsamples.	no *Phytophthora*
PR160817-CP11	*Arctostaphylos glauca*	Root density high, soil dry, a friable clay, sample under several mostly dead ARGL on uphill edge of manzanita stand adjacent to clearing. 3 subsamples.	no *Phytophthora*
PR160817-CP12	*Frangula californica*	Root density high, soil damp, sampled under dead veg along uphill edge of pond that appears to be mostly FRCA, live FRCA further upslope, 3 subsamples.	no *Phytophthora*
PR160817-CP13	forbs, grass, *Eleocharis sp.*	Pond, 3 subsamples, root density medium/low, soil moist, closer to road than CP12, left side of pond	*P.* taxon raspberry, *P. inundata* × *humicola*
PR160817-CP14	crabgrass, *Eleocharis sp.*	Other pond, 3 subsamples, root density high/moderate, soil moist, among area of extreme cattle punch	no *Phytophthora*

Sample number	Vegetation sampled	Sample Notes	***Phytophthora* species detected**
PR160817-CP15	crabgrass, bermudagrass, monocots	Other pond, 3 subsamples, root density high, soil wet, on other side pond from 14	*P.* taxon raspberry
PR170414-CP22	Artemisia californica, grass	Sampled area around edges of construction pad in conservation easement. Storage area, sand and gravel have been piled on pad. Samples included grass and California sagebrush roots. Cattle grazing. Sample root density- low, soil moisture- less than field capacity, dark gray, clay/clay loam, 4 subsamples.	no *Phytophthora*

Table 3.3.2-2. DNA sequencing details for *Phytophthora* detections in the north portion of Calero County Park.

Isolate number	PDR number	Identification	Sequencing result details
PR160817-CP13.4b	MV6P06578661	*Phytophthora* taxon raspberry	ITS: 100% (749/749); 100% to vouchered strains 92-209C & P1050
PR160817-CP13.7	MV6P06578660	*Phytophthora inundata X humicola*	ITS: *P. inundata* ex-type isolate P246b AF266791.1 804/806 (99%); P. humicola ex-type isolate 32F8=CBS200.81 KF112855.1 803/806 COX2: no ex-type COX2 sequences in GenBank. *Phytophthora humicola* 99% (546/547); *P. inundata* (542/547)
PR160817-CP15.6b	MV6P06578663	*Phytophthora* taxon raspberry	ITS: 100% (749/749); 100% to *P.* taxon raspberry vouchered strains 92-209C & P1050
PR160817-CP15.7b	MV6P06578662	*Phytophthora* taxon raspberry	ITS: 100% (749/749); matches 100% to *P.* taxon raspberry vouchered strains 92-209C & P1050

3.3.3. Calero County Park – south

We collected samples along trails originating at the east and south entrances of Calero County Park on 10 April and 29 December 2017. The April 2017 sampling included three water samples and three root/soil samples, whereas all seven samples from December 2017 were root/soil samples. Priority areas for sampling at this location were serpentine chaparral, blue and valley oak woodland, and areas along trails that connected with these areas. Sample locations are shown in Figures 3.3.3-2 and 3.3.3-3.

No *Phytophthora* was detected in the three terrestrial samples collected in April 2017 or from the Los Cerritos pond water sample (CP17). *Phytophthora ramorum* and *P. chlamydospora* were recovered from water samples collected from Llagas and Little Llagas Creeks (Tables 3.3.3-1 and 3.3.3-2) in April 2017. The only *Phytophthora* detection from the December 2017 sampling at this location was *P. cambivora*, baited from under a large *Quercus lobata* (CP28, Figure 3.3.3-1). This tree was located within a former walnut orchard and was near a trail and a constructed swale or ditch. *P. cambivora* was also found in association with declining blue oaks in Rancho Cañada de Oro OSP (RO01) at a point about 1.2 km to the southwest. There are no direct connections between these points, but soil from infested orchards in the area transported on equipment, footwear, or by livestock might be the source of the RO01 infestation.

Figure 3.3.3-1. *Phytophthora cambivora* was detected in a December 2017 root/soil sample collected under the valley oak at the center of the image. Remnant walnut orchard trees are visible around the oak. A drainage ditch (visible across image from left to right) and trail (to left of tree) also pass by the tree.

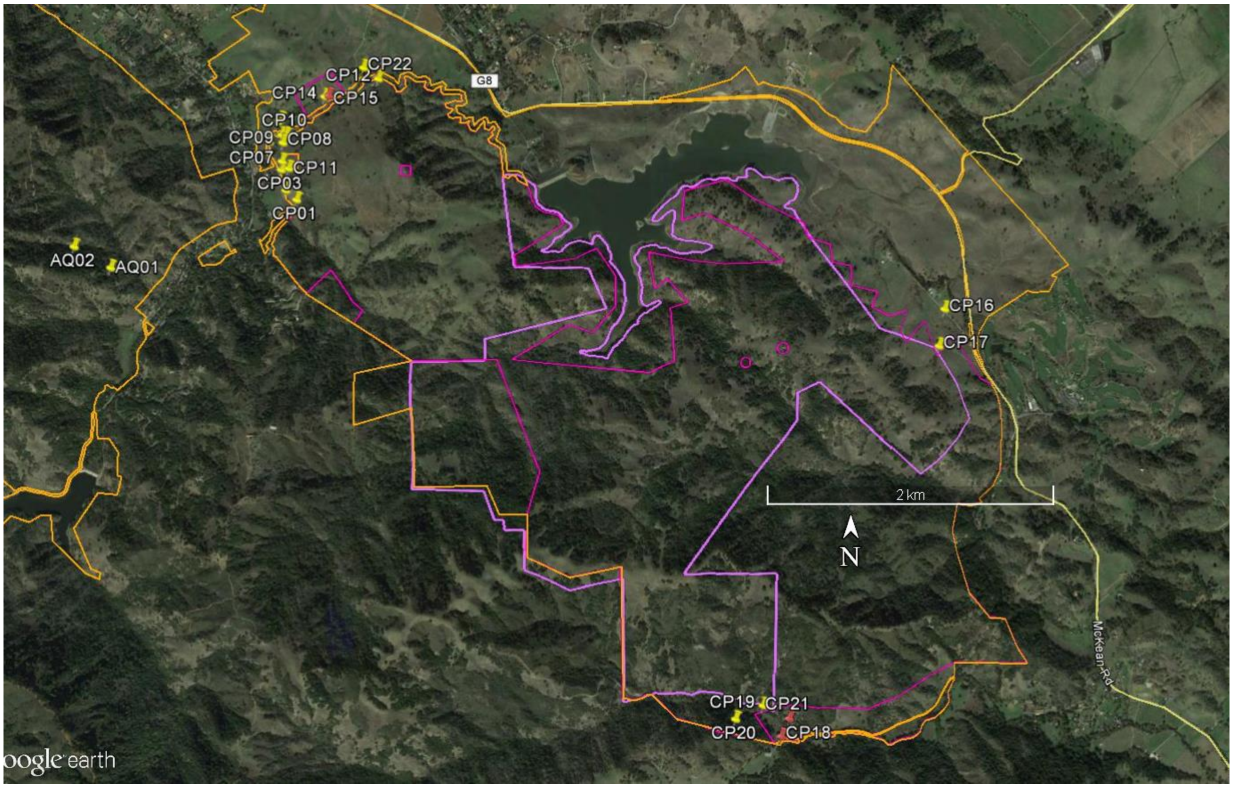

Figure 3.3.3-2. Sample sites near the east (CP16, 17 at right) and south (CP18-21 at bottom) entrances of Calero County Park on 10 April 2017. Sample sites in the north portion of the park (CP01-CP15, CP22) and some at Almaden Quicksilver Park (AQ01, 02) in the upper portion of the image are discussed above. Pink icons represent *Phytophthora* positive samples, yellow icons represent samples in which *Phytophthora* was not detected. Sample details and identifications for samples CP16-22 are shown in Tables 3.3.3-1 and 3.3.3-2.

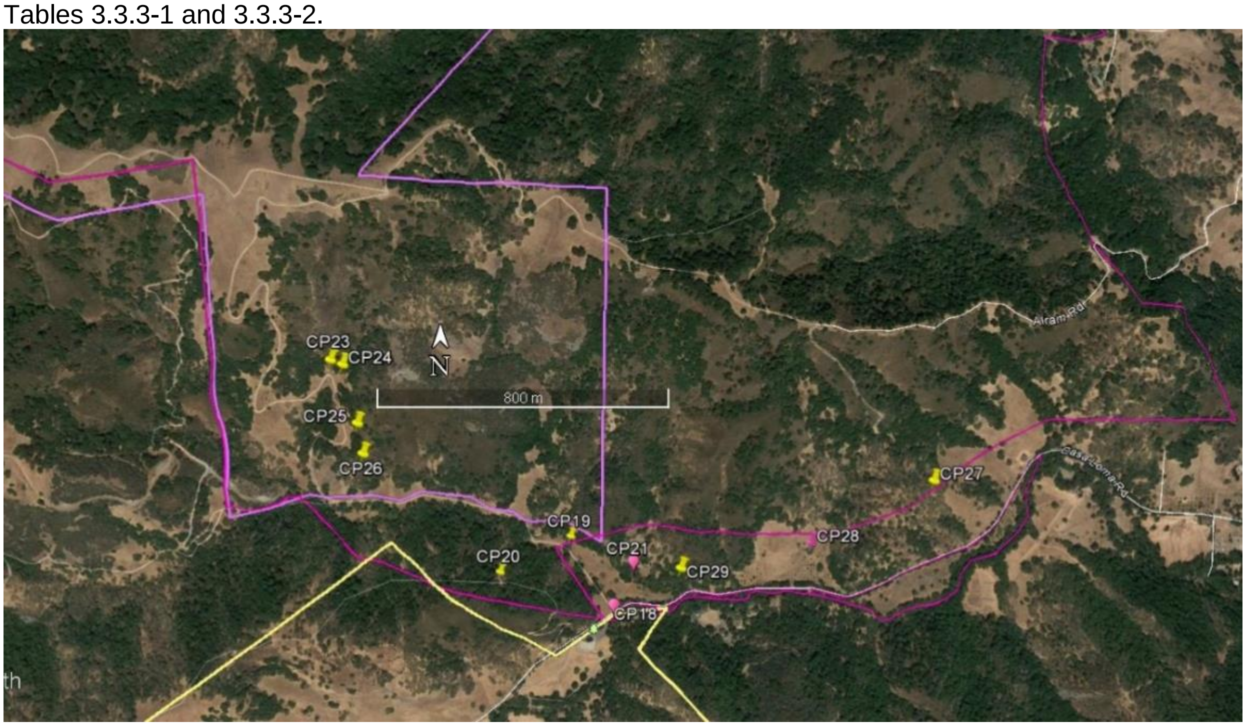

Figure 3.3.3-3. April and December 2017 sampling points near the south entrance of Calero County Park. Pink icons represent samples with *Phytophthora* detections. Inverted droplet icons represent water samples collected in April 2017.

Table 3.3.3-1. Samples collected in the southern portion of Calero County Park on 10 April and 29 December 2017 in mixed oak woodland and forest and mixed riparian woodland and forest habitat.

Sample number	**Vegetation sampled**	**Sample Notes**	***Phytophthora* species detected**
PR170410 -CP16	*Baccharis pilularis*	Just past Los Cerritos trail trailhead, old plants with dieback, young plants mostly look good. Sample root density-moderate, soil- moist, slightly sticky. 4 subsamples.	no *Phytophthora*
PR170410 -CP17	water	Los Cerritos pond. Perennial pond. 5 subsamples, water depth 50cm, water still, slightly turbid, brown. Temperature 67F. Surrounding vegetation *Scirpus*, cattail, *Eleocharis*, grass and forbs, mint.	no *Phytophthora*
PR170410 -CP18	water	Llagas Creek, perennial creek? 5 subsamples, water depth 30-40 cm, water fast flowing, clear, sample from rapids within 2 m of shore, under *Platanus* and California bay. Temperature 55F.	*Phytophthora ramorum**
PR170410 -CP19	*Quercus agrifolia, Juglans hindsii*	Longwall Canyon trail near junction with Little Llagas Creek trail. Sampled beneath 2 coast live oaks and 2 black walnuts, most roots from oaks, one oak 25-30cm DBH looks to be in poor condition, like it was defoliated last year, other looks ok, DBHs about 25-30 cm. 70cm DBH black walnut on its own roots looks good, other walnut is English walnut on black walnut root stock, has dieback. Sample root density-moderate, soil- moist, slightly sticky. 4 subsamples. soil temperature 55F.	no *Phytophthora*
PR170410 -CP20	*Arctostaphylos* sp.	Along Mayfair Ranch trail, in an area of trail work, cut off plants, downslope from trail. Sample root density low, soil moist, slightly sticky, reddish brown loam. 3 subsamples.	no *Phytophthora*
PR170410 -CP21	water	Little Llagas Creek, just past footbridge on upstream side, water depth about 10cm, flow rate moderate, clear, no algae, stony bottom, streamside vegetation includes poison oak, valley oak, grass, California sagebrush, snowberry, California bay, California sycamore. 5 subsamples, water temperature=55F.	*Phytophthora chlamydospora*
PR171229 -CP23	*Artemisia californica, Salvia mellifera, Diplacus aurantiacus. Stipa* sp.*, Acmisiphon glabra*	Serpentine chaparral type at edge of coast live oak woodland and serpentine grassland. High quality chaparral, plants mostly in good condition, a few *A. californica* declining, one dead *Diplacus*, plus one large dead unknown. Sampled from rootzones of dead or declining plants. Roots abundant in top 25 cm of soil profile. Soil: slightly moist, well granulated clay loam. Sample root density: high. Soil temperature 52 F. 4 subsamples.	no *Phytophthora*
PR171229 -CP24	*Toxicodendron diversilobum, Arctostaphylos glauca, Artemisia californica, Salvia mellifera, Diplacus aurantiacus. Baccharis pilularis*	Serpentine chaparral type at edge of woods along seasonal drainage and grassland. High quality chaparral, plants mostly in good condition. Roots abundant in top 25 cm of soil profile. Soil: slightly moist, well granulated clay loam. Sample root density: high. Soil temperature 52 F. 4 subsamples.	no *Phytophthora*

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR171229-CP25	*Toxicodendron diversilobum, Baccharis pilularis, Salvia mellifera, Diplacus aurantiacus. Heteromeles arbutifolia, Acmisiphon glabra, Frangula californica, Stipa* sp.	Serpentine chaparral type at edge of serpentine grassland. High quality chaparral, plants mostly in good condition. Roots abundant in top 25 cm of soil profile. Soil: slightly moist, well granulated clay loam. Sample root density: high. Soil temperature 45 F. 3 subsamples.	no *Phytophthora*
PR171229-CP26	*Quercus douglasii, Quercus agrifolia, Toxicodendron diversilobum, Artemisia californica*	Blue oak stand in area mapped as serpentine chaparral. Thick duff layer, lots of roots in upper 20cm. Soil: slightly moist, well granulated clay loam. Sample root density: high. Soil temperature 53 F. 4 subsamples.	no *Phytophthora*
PR171229-CP27	*Quercus douglasii, Toxicodendron diversilobum, grass*	Blue oak woodland, intergrades with chaparral lower on slope, few roots in upper 25 cm. Oaks look ok, short internodes, some thinning. Soil: slightly moist to dry, granulated clay loam. Sample root density: low/moderate. Soil temperature 51 F. 4 subsamples.	no *Phytophthora*
PR171229-CP28	*Quercus lobata*	Large valley oak, DBH 1 m, in old walnut orchard, next to swale that continues a drainage out of the hills. Short internodes, thinning, and many epicormics. Soil: dry to slightly moist, granulated clay loam. Sample root density: high. Soil temperature 50 F. 4 subsamples.	*Phytophthora cambivora*
PR171229-CP29	*Sequoia sempervirens, Umbellularia californica, Platanus racemosa, Quercus douglasii*	Old planted redwoods between toe of slope and old road, redwoods with severe dieback, PLRA about 0.6m DBH, QUDO about 0.5m DBH, redwoods 0.2 to 0.45m DBH. Soil: slightly moist, granulated to compacted clay loam. Sample root density: high. Soil temperature 49 F. 4 subsamples.	no *Phytophthora*

**Phytophthora ramorum* is distinctive in culture and was identified by its morphology.

Table 3.3.3-2. DNA sequencing details for *Phytophthora* isolates recovered during 10 April and 29 December 2017 sampling in the southern portion of Calero County Park. GenBank=National Center for Biotechnology Information (NCBI), *PhytID=Phytophthora*-ID.org; both maintain databases of *Phytophthora* genomic sequences.

Isolate number	PDR number	Identification	Sequencing result details
PR170410-CP21-3	MV6P06578746-3	*Phytophthora chlamydospora*	*Phytophthora chlamydospora* ITS: 100% (824/824)
PR171229-CP28-3	MV6P06578769-4	*Phytophthora cambivora*	*Phytophthora cambivora* ITS: 823/823 to neotype IT 5-3 GenBank KU899179.1

3.3.4. Coyote Lake/Harvey Bear Ranch County Park

We visited Coyote Lake/Harvey Bear Ranch County Park 18 December 2017 and 10 January 2018. During one of our visits, we observed a large herd of pigs along the access road and rooting by pigs was observed at multiple spots at this location. Four *Phytophthora* species were detected in six of 16 samples from this location (Tables 3.3.4-1 and 3.3.4-2)

Phytophthora crassamura was detected in mud from a wet trail in the southern portion of the park (CL06, Figure 3.3.4-1). Recent use by cattle had punched deep holes along and beside the trail in areas. *P. crassamura* was also detected in ephemeral runoff water we collected alongside the county road in the north end of the park (CL16, Figure 3.3.4-2) . The latter area received runoff from an area where nursery stock had been planted. No *Phytophthora* species were detected from two water samples collected from the southern portion of the park (CL09 and CL10, Figure 3.3.4-1). We also detected *P. pseudocryptogea* and *P. cambivora* along the county road at two different pullouts / picnic areas that receive heavy use by park visitors. Pig rooting was evident at one of these sites. These detections are all in areas that pose a risk of secondary spread into sensitive habitat within the reserve area.

Within the reserve area, *P. cambivora* was detected under a *Q. lobata* (CL03) that was downslope from a trail in an area with heavy cattle use. We also detected *P. gonapodyides* in water sampled from a puddle near the canopy of an upland *Q. lobata* (CL14), although *Phytophthora* was not detected in a separate sample under the canopy of the tree about 10 m from the puddle. This area also had evidence of heavy cattle use.

Figure 3.3.4-1. Locations and detected *Phytophthora* species for samples collected 10 January 2018 in the southern part of Coyote Lake Harvey Bear Ranch County Park. Pink icons represent samples with *Phytophthora* detections. Purple outline is the reserve border.

Figure 3.3.4-2. Locations and detected *Phytophthora* species for samples collected 18 December 2017 and 10 January 2018 in the northern part of Coyote Lake Harvey Bear Ranch County Park. Pink icons represent samples with *Phytophthora* detections, inverted drop icons are water samples. Purple outline is the reserve border.

Table 3.3.4-1. Samples collected at Coyote Lake Harvey Bear County Park on 18 December 2017 and 10 January 2018.

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR171218 -CL01	*Quercus lobata, Quercus agrifolia, Heteromeles arbutifolia*	At Calaveras picnic area. Toyon very healthy, large diameter oaks estimate 0.6 to 0.9m DBH with 20 to 50% dieback, pig rooting evident. Sample root density: high. Soil: heavy clay loam, cloddy, slightly moist, soil temperature 48 F. 4 subsamples.	*Phytophthora cambivora*
PR171218 -CL02	*Pinus sabiniana, Heteromeles arbutifolia, Quercus agrifolia*	Area of declining PISA upslope from trail, canopy dieback trees varies from 50 to 100%. Toyon and QUAG look good. PISA about 20 to 30 cm DBH, did not see western gall rust or dwarf mistletoe. Sample root density: moderate. Soil: loam, moist, soil temperature 47 F. 3 subsamples.	no *Phytophthora*
PR171218 -CL03	*Quercus lobata, Toxicodendron diversilobum, Pinus sabiniana*	Large QULO 1.6 m DBH, severe thinning, dieback between 20 and 50%, low vigor, short internodes, numerous cow pies. Small PISA, about 10cm DBH has western gall rust. Sample root density: high. Soil: heavy clay loam, cloddy, slightly moist. 3 subsamples.	*Phytophthora cambivora*
PR171218 -CL04	*Pinus sabiniana*	Brown and wilting PISA DBH less than 10 cm, canopy diebacks of 50% up to 80%, western gall rust and dwarf mistletoe observed. 2 green large DBH about 1m, root failed QUAG just upslope. Sample root density: high. Soil: clay loam, slightly moist, soil temperature 46F. 3 subsamples.	no *Phytophthora*
PR171218 -CL05	*Acacia* sp., *Eucalyptus* sp.	Grove of acacia, several with dead leaders, others with varying amounts of dieback, up to 80%, mostly DBH < 10 cm, a few larger, up to 15 cm, one eucalyptus. Sample root density: moderate/high. Soil: cloddy, heavy clay loam, nearly dry, soil temperature 52 F. 3 subsamples.	*Phytophthora pseudocryptogea*
PR180110 -CL06	mud and leaves stuck to bottom of boots	One day after rain, no sunshine yet, sample contains mud from 4 boots and 3 walking sticks picked up from Mendoza Ranch and Rancho La Polka trails, and grass blades and coast live oak leaves that were stuck to the mud. No obvious roots. Soil: very moist, sticky clay.	*Phytophthora crassamura*
PR180110 -CL07	*Quercus douglasii*	Two trees, DBH 0.25 and 0.3 m, at hilltop location with picnic table, road and trial access. Thin, short internodes, smaller tree with many epicormic sprouts. Heavy cattle use, open grown hill top position, hasn't totally defoliated yet. Soil: even though rainfall previous day, soil not wetted below 10 cm depth. Texture variable, clay loam to sandy loam over decomposing parent material. Sample root density: moderate. Soil temperature 56 F. 4 subsamples.	no *Phytophthora*
PR180110 -CL08	*Quercus lobata*	Single tree, DBH 0.9 m, thin, short internodes, open grown hill top position, hasn't totally defoliated yet. Soil: moist clay loam. Sample root density: moderate/high. Soil temperature 55 F. 4 subsamples.	no *Phytophthora*
PR180110 -CL09	water	Runoff in cattle exclosure. Vegetation grass, forbs, and Juncus. Very slow flow, max depth about 6 cm. Water temperature 55, 6 subsamples.	no *Phytophthora*
PR180110 -CL10	water	Large pond, shoreline vegetation grass, forbs, dormant bulrush, coast live oaks on one side. Bottom muddy, nothing growing in pond. Sampled surface water where water depth about 10 cm, 6 subsamples, water temperature 55 F.	no *Phytophthora*
PR180110 -CL11	*Quercus lobata*	Two very thinned and stressed looking trees on hill top near trailhead, 0.8 -0.9 m DBH. No roots found for one tree. Soil: wet, sandy clay loam, not overly compacted. Sample root density: low. Soil temperature 54 F. 4 subsamples.	no *Phytophthora*

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR180110-CL12	*Quercus lobata, Quercus agrifolia, Platanus racemosa* X	Transplants on uphill side of parking lot at trailheads at Mendoza Ranch entrance. DBH from 0.5 to 6 cm. All have some degree of thinning and dieback. Soil: wet, clay loam, some subsamples have nursery mix. Sample root density: high. Soil temperature 55 F. 3 subsamples.	no *Phytophthora*
PR180110-CL13	*Quercus lobata*	Large open grown tree about 1.1 m DBH, in shallow bowl formed by the surrounding hills. Tree thin, some epicormics. Soil: moist, surface hard pan present, massive sandy clay loam, looks composited, rust streaks present. Sample root density moderate. 3 subsamples.	no *Phytophthora*
PR180110-CL14	water	Puddle about 10 m from trunk of *Quercus lobata* sampled for CL13. Puddle about 2.5 x 4 m, max depth about 3-4 cm, bottom muddy, cow manure present, 6 subsamples, water temperature 55 F.	*Phytophthora gonapodyides*
PR180110-CL15	*Quercus agrifolia, Toxicodendron diversilobum,* grass, forbs	Stand of coast live oak along hillslope in various degrees of decline, DBH range 0.4 to 0.7 m, one root fail. Soil: moist, clay loam, fluffy and well granulated. Sample root density: high. Soil temperature 53 F. 3 subsamples.	no *Phytophthora*
PR180110-CL16	water	Collected across about 40 m of runoff alongside road. Upslope from road are planted coast live oak, further uphill is natural coast live oak forest. Vegetation along runoff is grass and forbs. Maximum depth about 10 cm.	*Phytophthora crassamura*

Table 3.3.4-2. DNA sequencing details for *Phytophthora* isolates recovered during 17 Dec 2017 and 10 Jan 2018 sampling at Coyote Lake Harvey Bear County Park. GenBank=National Center for Biotechnology Information (NCBI), *PhytID=Phytophthora*-ID.org; both maintain databases of *Phytophthora* genomic sequences.

Isolate number	PDR number	Identification	Sequencing result details
PR171218-CL01-1	MV6P06578765-3	*Phytophthora cambivora*	*Phytophthora cambivora* ITS: 823/823(100%) to Neotype IT 5-3 GenBank KU899179.1
PR171218-CL03-1	MV6P06578765-4	*Phytophthora cambivora*	*Phytophthora cambivora* ITS 823/824(99%) to Neotype IT 5-3 GenBank KU899179.1
PR171218-CL05-5	MV6P06578765-5	*Phytophthora pseudocryptogea*	*Phytophthora pseudocryptogea* ITS: ex-type SUC620 GenBank KP288373.1 (762/763)
PR171218-CL05-7	MV6P06578765-6	*Phytophthora pseudocryptogea*	*Phytophthora pseudocryptogea* ITS: ex-type SUC620 GenBank KP288373.1 (762/763)
PR180110-CL06-1	MV6P06578746-3	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: GenBank (819/819) PhytID (756/756)
PR180110-CL14-4	MV6P06578770-2	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: Only one direction PHYR is clean. GenBank (744/744) PhytID (691/691)
PR180110-CL16-1	MV6P06578770-3	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: GenBank (818/818) PhytID (806/806)

3.3.5. Coyote Valley Open Space Preserve

We visited Coyote Valley Open Space Preserve on 28 June 2017 and 18 Jan 2018, collecting a total of seven root/soil samples. Upland samples included one within serpentine chaparral (CV02) that was mapped as grassland habitat. Other upland samples were taken in blue or valley oak woodland. In one area (CV06), an uncommon mixture of blue and California black oak was sampled. We also collected two samples along a dry seasonal creek near a trail crossing (CV01, CV04) and at the edge of a cattle pond below the serpentine chaparral. The only *Phytophthora* detected at this location was *Phytophthora riparia*, which was recovered from the muddy soil at the edge of the cattle pond (Table 3.3.5.-1, Figure 3.3.5-1).

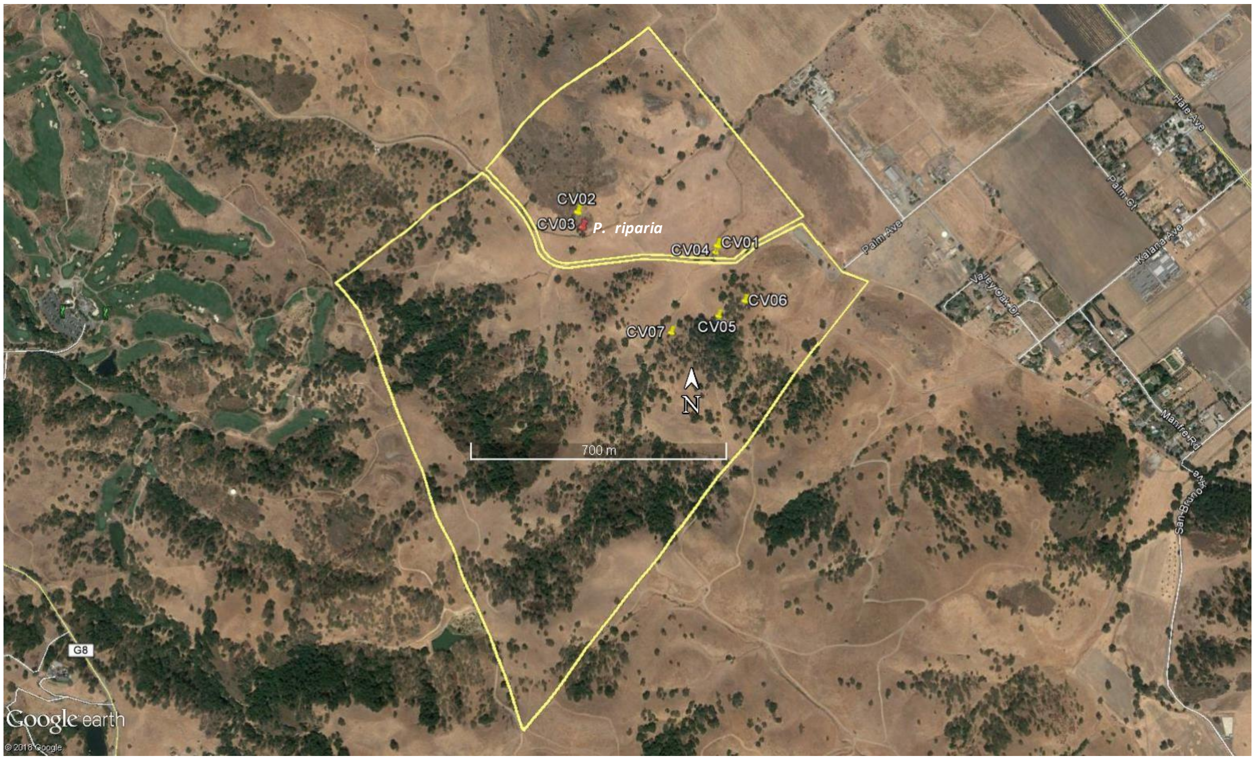

Figure 3.3.5-1. Samples collected at Coyote Valley Open Space Preserve on 28 June 2017. Pink icons represent *Phytophthora* positive samples, yellow icons represent *Phytophthora* negative samples. Yellow outline represents the reserve border. Sample details and identifications are shown in Table 3.3.5-1 and 3.3.5-2.

Table 3.3.5.-1. Samples collected at Coyote Valley Open Space Preserve on 28 June 2017 and 15 January 2018.

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR170628 -CV01	*Quercus lobata*	Sample collected under 80cm DBH valley oak, tag #575, near trail not far from entrance. Some exposed roots collected from dry creek next to tree. Tree shows a little canopy thinning, otherwise ok. Sample root density- low/moderate, soil- loam to clay loam. 3 subsamples. Soil temperature 75F.	no *Phytophthora*
PR170628 -CV02	*Arctostaphylos* sp.	Sampled under an OK looking manzanita on a slope above a pasture. Below and above this plant is a dead manzanita. Around these plants are *Artemisia californica*. These look somewhat dry with a little dieback, but generally ok. A small *Quercus agrifolia* with 1 cm DBH looks fine. Further upslope is a 20 cm DBH Q*. lobata* with a lot of dieback. Sample root density- moderate, soil- dry, granular, non-massive. 3 subsamples.	no *Phytophthora*
PR170628 -CV03	*Nasturtium officinale*, grass, *Salix* sp.	Collected from zone of saturated soil, ponded water in cattle grazed area. Sample root density- moderate, look dead. Soil- saturated, clay loam.	*Phytophthora riparia*
PR180115 -CV04	*Quercus lobata*	Large open grown QULO in drainage near trail, DBH approx 1 m. Looks ok but has decay of some sort on base trunk. Roots difficult to find, most came from swale. Sample root density: high. Soil: moist, rocky, sandy. Soil temperature 55F. 4 subsamples.	no *Phytophthora*

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR180115 -CV05	*Quercus douglasii, Umbellularia californica*	Sampled 80 cm DBH QUDO and smaller, multistemmed UMCA, lowest position trees in ravine. QUDO looks good. Upslope are more bay, some with dead tops and chlorosis. No symptoms of SOD on leaves of UMCA. Sample root density: high. Soil: moist, sandy loam. Soil temperature 53 F. 4 subsamples.	no *Phytophthora*
PR180115 -CV06	*Quercus kelloggii, Quercus douglasii*	Upper slope, an unusual mixed stand of blue and black oaks. QUDO ok to scraggly, QK with lots of wood decay, several falling apart, DBH range among trees 30- 50 cm. Sample root density: moderate/high. Soil: sandy clay loam. Soil temperature 53 F. 4 subsamples.	no *Phytophthora*
PR180115 -CV07	*Quercus lobata*	Three scraggly QULO beside trail, DBH 30-40 cm. Short internodes, thinning, severe epicormics, several have died, several root failures in area, looks like root disease area. Sample root density: low/moderate. Soil: moist, sandy clay loam. Soil temperature 55 F. 3 subsamples.	no *Phytophthora*

Table 3.3.5.-2. DNA sequencing details for *Phytophthora* isolates recovered from 28 June 2017 sampling at Coyote Valley Open Space Preserve. GenBank=National Center for Biotechnology Information (NCBI), *PhytID=Phytophthora*-ID.org; both maintain databases of *Phytophthora* genomic sequences.

Isolate number	PDR number	Identification	Sequencing result details
PR170628-CV03-1	MV6P06578756	*Phytophthora riparia*	*Phytophthora riparia* ITS: 100% to Ex-type CPHST BL 111 GenBank MG865583.1 (604/604) one way.

3.3.6. Joseph D. Grant County Park

We visited Joseph D. Grant County Park on 21 December 2017. We had planned to sample in blue oak woodland, but the vegetation type was not correctly mapped in the GIS vegetation layer. The areas mapped as blue oak that we visited were actually valley oak woodland; we did not observe any blue oak woodland at this location. Consequently, most of our samples were collected in or near valley oak woodland.

We recovered three *Phytophthora* species from two samples along waterbody edges: *P. gonapodyides, P. riparia,* and *P.* taxon raspberry (Tables 3.3.6-1 and 3.3.6-2, Figure 3.3.6-1). One sample (JG07) was from the edge of a cattle pond accessible to park visitors by a trail (Bass Lake) and the other (JG05) was from the edge of a dry seasonal channel along a trail that was lined with willows.

We also isolated *P. cambivora* from poor-looking planted nursery stock near a parking area off SR130 in the upper part of the watershed (JG08). The placement of this infected material was especially unfortunate because it is at the upper part of the watershed; contamination that could spread from this site has the potential to infest a very large area of downslope habitat. A mitigating factor is that the nursery stock was not close to other host vegetation. Hence, it would be possible to attempt a spot eradication of the local infestation at the plantings sites, potentially using solarization.

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Figure 3.3.6-1. December 2017 sampling points at Joseph D. Grant County Park. Pink icons represent samples with *Phytophthora* detections. Sampling details and identifications are shown in Tables 3.3.6-1 and 3.3.6.-2.

Table 3.3.6-1. Samples collected at Joseph D. Grant County Park on 21 December 2017.

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
JG01	*Platanus racemosa* (or hybrid)	In flat highly impacted group picnic area in grove of planted sycamores, plants generally asymptomatic. Samples collected around three sycamores, DBH about 30cm, current internode growth short. Soil: slightly to moderately moist, variable textures, sandy loam to clay loam, probably fill. Sample root density: moderate. Soil temperature 40 F. 3 subsamples.	no *Phytophthora*
JG02	*Quercus agrifolia, Quercus kelloggii, Toxicodendron diversilobum,* grass, *Carduus pycnocephalus*	Hilltop adjacent to star-watching amphitheater, heavy use area. Large, >1.4m DBH QUAG with severe thinning and canopy dieback rating of 20-50%. QUKE with canopy dieback rating about 20%. Sample root density: moderate. Soil: rocky, light loam, slightly moist, soil temperature 47F. 4 subsamples.	no *Phytophthora*
JG03	*Quercus lobata, Toxicodendron diversilobum,* grass, *Carduus pycnocephalus*	Declining trees, DBH of 25 to 50cm, valley oak forest on hill slope, veg map has this area as blue oak woodland type, but there are no QUDO here. Sample root density: moderate. Soil: rocky, light loam, slightly moist, soil temperature 44F. 4 subsamples.	no *Phytophthora*
JG04	*Quercus lobata*	Declining QULO, short internodes, thinning, canopy dieback ratings of 50% to 80%, DBHs of 30 to 40 cm, valley oak forest on hill slope, veg map has this area as blue oak woodland type, but there are no QUDO here. Sample root density: moderate. Soil: rocky, light loam, slightly moist, soil temperature 48 F. 3 subsamples.	no *Phytophthora*
JG05	*Salix* spp.	Shallow channel and bypass channel next to road and marsh, about 10 m from base of slope, many *Salix* have dead wood where diameters are > 20cm. Sample root density: high. Soil: moist, silty, sandy to slightly clayey alluvium, soil temperature 44 F. 3 subsamples.	*Phytophthora riparia*
JG06	*Quercus lobata*	Bass Lake area (really a cattle pond). QULO on sloped bench above picnic table, look ok, DBH about 0.6 m, sampled under the worst looking one, has short internodes, thinning. Pig mud on lower trunks here. Sample root density: moderate. Soil: almost dry, cloddy loam, soil temperature 44F. 3 subsamples.	no *Phytophthora*
JG07	*Salix* sp., grass, *Mentha pulegium*	Bass Lake area (really a cattle pond). *Salix* max DBH 20cm, at high water mark of tank, inlet side, now many meters from water line, heavy cattle use area, although cattle not yet present this season. Sample root density: very high. Soil: slightly moist clay loam, hard and difficult to dig. 4 subsamples.	*Phytophthora gonapodyides, P. taxon raspberry*
JG08	*Quercus lobata*	Flat area of large QULO, DBHs of 0.7 to 1 m a short walk uphill from trailhead parking lot. Mostly appear healthy, but some wood decay/canker rot, *Inonotus dryophilus* conk observed. Very difficult to find roots, dug at least 6 holes. Sample root density: very low. Soil: nearly dry cloddy clay loam, soil temperature 47F. 3 subsamples.	no *Phytophthora*
JG09	*Quercus kelloggii*	Three transplanted QUKE next to parking lot. Planted very deep, largest one looks ok, about 3 cm DBH. Other two in very poor condition, below 1 m tall, DBH 0.5 cm. Sample root density: very low. Soil: very slightly moist sandy loam. 3 subsamples.	*Phytophthora cambivora*

Table 3.3.6-2. DNA sequencing details for *Phytophthora* isolates recovered from samples collected at Joseph D. Grant County Park on 21 December 2017*.* GenBank=National Center for Biotechnology Information (NCBI), *PhytID=Phytophthora*-ID.org; both maintain databases of *Phytophthora* genomic sequences.

Isolate number	PDR number	Identification	Sequencing result details
PR171221-JG05-1	MV6P06578766-1	*Phytophthora riparia*	*Phytophthora riparia* ITS: 820/822 to ex-type CPHST BL 111 GenBank MG865583.1
PR171221-JG07-2	MV6P06578766-2	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: Only one seq. direction. GenBank (750/750) PhytID (641/641)
PR171221-JG07-5	MV6P06578766-3	*Phytophthora* taxon raspberry	*Phytophthora* taxon raspberry (PhytID -761/761*)*
PR171221-JG07-7	MV6P06578767-1	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: GenBank (802/803) PhytID (802/803)
PR171221-JG09-6	MV6P06578766-4	*Phytophthora cambivora*	*Phytophthora cambivora* ITS: 823/824(99%) to Neotype IT 5-3 GenBank KU899179.1

3.3.7. Palassou Ridge OSP

Two water samples and three root/soil samples were collected from *Platanus racemosa* alluvial woodland at Palassou Ridge OSP on 29 March 2017. Three additional water samples and one soil/root sample were collected 17 May 2017 (Tables 3.3.7-1 and 3.3.7-2, Figure 3.3.7-1). *Phytophthora gonapodyides* and a strain from the *P. megasperma* complex were identified from one root/soil and one water sample, respectively, collected on 29 March 2017. *P. gonapodyides* is a clade 6 species most frequently found in water. We have occasionally detected it in root/soil samples collected in recently flooded areas, as was the case in this site. *P. megasperma* is a well-known pathogen of terrestrial plants. We have detected *P. megasperma* in water in other locations in association with runoff following winter rainstorms. The closest match for the isolate we obtained was an isolate identified as *P. megasperma* from roots of *Abies procera* (noble fir) at a Christmas tree farm in Washington (McKeever and Chastagner 2016).

Samples collected on 17 May 2017 (PR06 – PR09) were either upstream from or resamples in the same areas as the March 2017 positive samples. The only *Phytophthora* detections in the May 2017 sampling were of *Phytophthora* species closest to *P. lacustris*, detected in two of the water samples. These isolates differ from curated collections of *P. lacustris* by 2 to 3 base pairs (Table 3.3.7-2). *P. lacustris* is another clade 6 species normally found in water and appears able to hybridize with other closely related clade 6 species.

Figure 3.3.7-1. Samples collected at Palassou Ridge OSP on 29 March and 17 May 2017 in *Platanus racemosa* alluvial woodland. Pink icons represent *Phytophthora* positive samples, yellow icons represent *Phytophthora* negative samples. Sample details and identifications are shown in Tables 3.3.7-1 and 3.3.7-2.

Table 3.3.7-1. Samples collected at Palassou Ridge OSP on 29 March and 17 May 2017 in or near *Platanus racemosa* alluvial woodland habitat.

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR170329 -PR01	water	Downstream end creek, 6 subsamples, water depth 5-10 cm, water flow low-moderate; within 3 m of bank, part of main channel braiding; water clear; vegetation-sycamores, thin mulefat; cattle graze area, lots of cattle punch in bank; creek had overflowed bank	no *Phytophthora*
PR170329 -PR02	*Platanus racemosa*	One large DBH (80 cm DBH) and 1 smaller (~22 cm DBH), above wrack line, anthracnose but no obvious decline. Sample root density-low; soil-moist, sandy alluvium; 5 subsamples. Soil temp=52F.	no *Phytophthora*
PR170329 -PR03	water	Upstream from PR01. 6 subsamples, water depth up to 1 m, water flow moderate, within 2 m of bank near submerged sycamore roots, water clear, temperature 56F; vegetation-sycamores, coast live oak, mulefat; scoured area with cobbles, split half of main flow.	*Phytophthora megasperma* complex
PR170329 -PR04	*P. racemosa, Umbellularia californica, Toxicodendron diversilobum*	Edge of scour under trees adjacent to road, edge of pavement ~3 m from sample, and beyond barbed wire fence. Sample root density- high; soil- moist, sandy alluvium; 3 subsamples.	no *Phytophthora*

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR170329-PR05	*P. racemosa, Quercus agrifolia, Toxicodendron diversilobum*	Partially scoured area near bank creek, some sand deposition, some scour, this sample area had been flooded to a depth of 0.5 - 1m. No obvious symptoms. Sample root density- mod/high; soil- moist, sandy alluvium and some underlying loam; 3 subsamples.	*Phytophthora gonapodyides*
PR170517-PR06	water	Tributary to Coyote Creek, sampled upstream from bridge at start of Gilroy Hot Springs Rd by CDF fire station, water depth about 1 m, flow rate moderate, clear, some green strands algae, bottom sandy, gravelly. Streamside vegetation includes mulefat, coast live oak, snowberry, California bay, wild grape. 4 subsamples.	no *Phytophthora*
PR170517-PR07	water	Coyote Creek, water depth about 25 cm, flow rate moderate, clear, bottom gravelly. Streamside vegetation includes mulefat and willows. 4 subsamples within 3 meters of bank	*Phytophthora lacustris* complex
PR170517-PR08	water	Resample near PR03. Coyote Creek, sycamore roots in river, 3 subsamples near roots, where water has started to pond, although still filters out through the soil, and 2 upstream about 150 ft, water depth about 50 cm, flow rate moderate, clear, bottom gravelly. Streamside vegetation includes mulefat, California bay, and sycamores. 4 subsamples within 3 meters of bank.	*Phytophthora lacustris* complex
PR170517-PR09	*Umbellularia californica*	Above creek scour, plant yellow and thin with fine twig dieback. Nearby small sycamore 5 m away dead, another thin bay is 10 m away. Sample root density- high, soil- dry and silty, 3 subsamples. Soil temp 60F @ 10cm.	no *Phytophthora*

Table 3.3.7-2. DNA sequencing details for *Phytophthora* isolates recovered during 29 March and 17 May 2017 sampling at Palassou Ridge OSP in or near *Platanus racemosa* alluvial woodland habitat*.*

Isolate number	PDR number	Identification	Sequencing result details
PR170329-PR03-3	MV6P06578744-1	*Phytophthora megasperma* complex	*Phytophthora megasperma* ITS: 99% (803/806 to ex-type CBS40272 GenBank HQ643275.1. Also (817/818) to KU053273 from roots *Abies procera* (noble fir) Xmas tree farm WA state.
PR170329-PR05-1	MV6P06578744-2	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: 100% (808/808)
PR170329-PR05-2	MV6P06578744-3	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: 100% (811/811)
PR170517-PR07-6	MV6P06578748-1	*Phytophthora lacustris* complex	*Phytophthora lacustris* ITS: 802/805 (99%) to type GenBank JQ626605.1
PR170517-PR08-2	MV6P06578748-2	*Phytophthora lacustris* complex	*Phytophthora lacustris* ITS: 806/809 (99%) to type GenBank JQ626605.1
PR170517-PR08-3	MV6P06578748-3	*Phytophthora lacustris* complex	*Phytophthora lacustris* ITS: 99% (792/794)
PR170517-PR08-5	MV6P06578748-4	*Phytophthora lacustris* complex	*Phytophthora lacustris* ITS: 99% (810/813) to type GenBank JQ626605.1
PR170517-PR08-6	MV6P06578748-5	*Phytophthora lacustris* complex	*Phytophthora lacustris* ITS: 99% (807/810)

3.3.8. Santa Teresa County Park

Initial sampling was conducted at Santa Teresa County Park on 10 April 2017. Sampling included two sites in serpentine chaparral, one sample from a drainage, another in a flat above a creek, a sample of planted nursery stock, and one water sample from an intermittent creek. *Phytophthora chlamydospora*, a clade 6 species, was detected in the water sample. The only *Phytophthora* detected in the root/soil samples was collected beneath California bay trees in a drainage that showed significant canopy dieback

(STP03, Figure 3.3.8-1). The ITS sequence of this isolate is two to five base pairs different from ex-type cultures of *P. europaea*. The isolate from sample STP03 completely matches an isolate baited from a stream near Corvallis, OR (VI_1-2P; GenBank HM004226.1; Reeser et al 2011), and is one base pair different from an isolate from forest soil under *Q. alba* in West Virginia (BM 1/10; GenBank DQ313222; Balci et al 2007). Although *Phytophthora* was not detected in the nursery stock sample (STP06), these plants had been planted very deep in heavy clay soil, and we were unable to dig deep enough to adequately sample the root ball area where *Phytophthora* would be most likely to be found.

We returned Santa Teresa park on 28 June 2017 to conduct follow-up testing that might indicate the source of the *P. europaea*-like infestation (STP03). To do this, we sampled locations further up the drainages that connect to the STP03 sample site and cross the Stile Ranch and Mine trails south of Bernal Road (Figure 3.3.8-2). We did not detect the *P. europaea*-like species, but instead detected four other species: a strain in the *P. cryptogea* complex, *P. inundata*, *P. multivora*, and *P. pseudocryptogea* (Tables 3.3.8-1, 3.3.8-2). The presence of this diversity of *Phytophthora* species is consistent with a nursery-stock source. The sampled drainages are downhill from two landscaped facilities and a former orchard area that might be the source of most or all of the species detected (Figure 3.3.8-3). Potentially a mixed source of *Phytophthora* upslope could segregate into distinct infestations downslope based on hosts present. Cattle and possibly other animals, as well as park users, may also be involved in moving *Phytophthora* inoculum between and along drainages.

Figure 3.3.8-1. A *Phytophthora europaea*-like strain was recovered from roots and soil collected beneath these California bay trees at Santa Teresa County Park on 10 April 2017 (STP03).

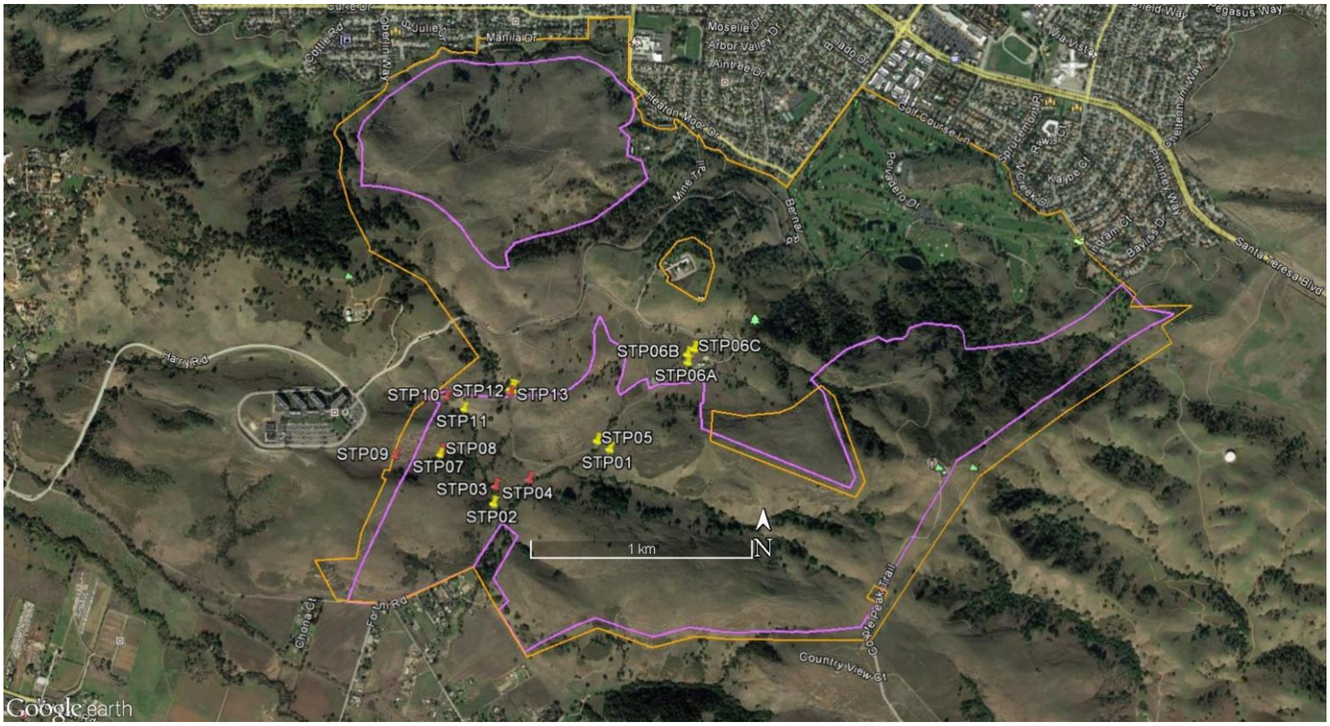


Figure 3.3.8-2. Samples collected at Santa Teresa County Park on 10 April (STP01-STP06) and 28 June 2017 (STP07-STP13). Pink icons represent *Phytophthora* positive samples, yellow icons represent samples in which *Phytophthora* was not detected. Sample details and identifications are shown in Tables 3.3.8-1 and 3.3.8-2.

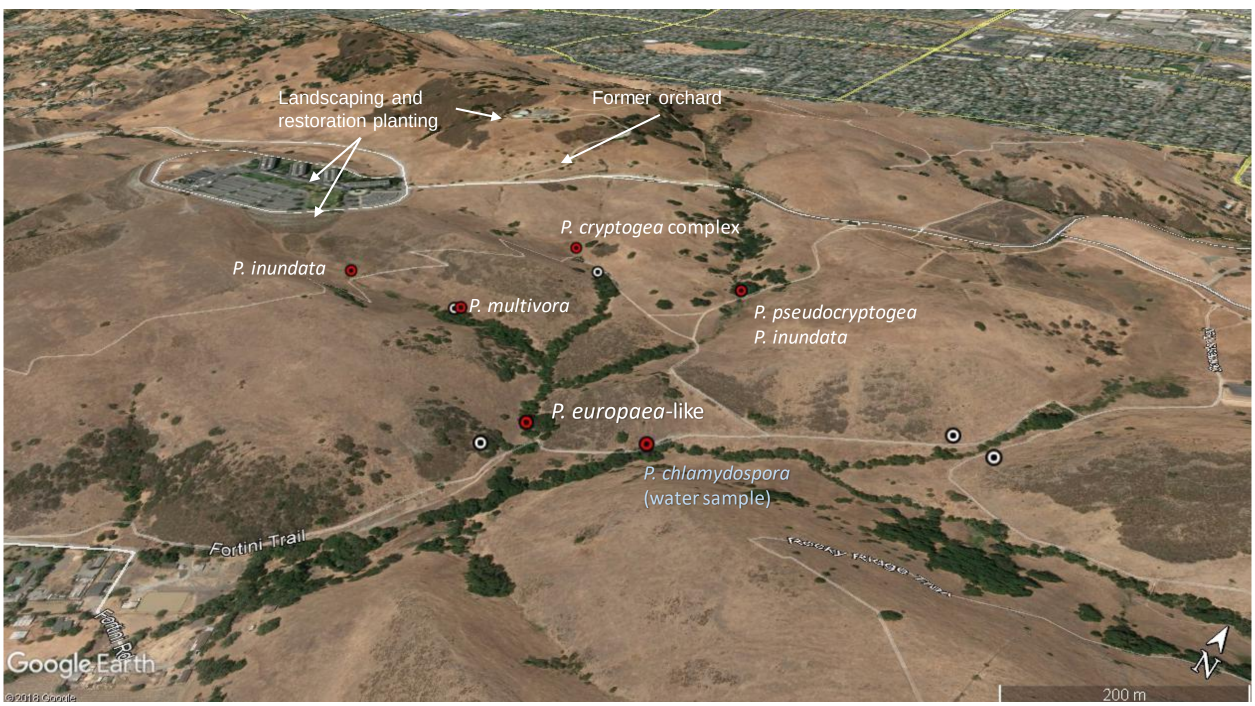


Figure 3.3.8-3. Results of collected at Santa Teresa County Park on 10 April and 28 June 2017 relative to potential sources of inoculum. Red icons represent *Phytophthora* positive samples, white icons represent samples in which *Phytophthora* was not detected. Sample details and identifications are shown in Tables 3.3.8-1 and 3.3.8-2.

Table 3.3.8-1. Samples collected at Santa Teresa County Park on 10 April and 28 June 2017 .

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR170410-STP01	*Artemisia californica*	Rocky area above Rocky Ridge trail downslope from rock wall. Cattle grazed but light use due to rockiness. Some dieback of California sagebrush. Sample root density- moderate, soil moisture-moist, loamy, well granulated. 4 subsamples.	no *Phytophthora*
PR170410-STP02	*Arctostaphylos* sp.	On slope above Mine trail. Severe dieback of *Arctostaphylos* sp., California sagebrush, sage, and coast live oak look good. Cattle-grazed but light use due to rockiness. Some dieback of California sagebrush. Sample root density high, soil moist, slightly sticky, loam, good structure and tilth. 4 subsamples.	no *Phytophthora*
PR170410-STP03-1	*Umbellularia californica, Quercus agrifolia, Quercus lobata*	Along ephemeral drainage that crosses Mine trail, currently with water. Social trails and cement cattle trough. Bay looks chlorotic and has some dieback aloft, coast live oak and valley oak look ok, *Baccharis* with severe dieback. Root density very high under canopy. Samples collected within 4 m of drainage. Sample root density high, soil moist, very clayey and sticky, 4 subsamples.	*Phytophthora* taxon europaea-like
PR170410-STP04-1	water	Social picnic area downslope from Mine trail at intermittent creek. Creek flows across trail. 5 subsamples, water depth 5-10 cm, water flow moderate, within 1 m of bank, water clear with gravelly creek bottom, temperature 56F, vegetation-California bay, coast live oak, poison oak, *Rubus*. Bay has thinning and dieback, others look good.	*Phytophthora chlamydospora*
PR170410-STP05	*Heteromeles arbutifolia, Frangula californica, U. californica*	Downslope from Mine trail, Sampled under declining coffeeberry, thin toyon, and somewhat chlorotic bay. Sample root density high, soil quite moist, sticky, clayey. 4 subsamples.	no *Phytophthora*
PR170410-STP06	*Q. agrifolia, Q. lobata*	Sampled 1 coast live oak and 2 valley oak transplants, widely separated and near parking area. All show severe decline and dieback. Plants all same vintage, current DBH about 5-7 cm. Sample root density low, soil quite moist, very sticky, clayey, dark gray. 3 subsamples.	no *Phytophthora*
PR170628-STP07	*U. californica*	Upstream of sampling point STP03, downslope from Stile Ranch trail, alongside creek. Bay has high branch dieback, thinning, many chlorotic leaves. Sample root density high, many roots dark brown and shriveled. Soil slightly moist, sticky, clay loam, no duff. Inundated at high flow, currently 0.5 to 1 m above water level in adjacent creek. 3 subsamples.	no *Phytophthora*
PR170628-STP08	*U. californica, Q. agrifolia*	Near STP07. Considerable chronic thinning and dieback, 20-50% of canopy. Sample root density- high, some roots discolored and dead. Soil dry, hard, blocky, clay to heavy clay loam. Inundated at high flow, currently 0.5 to 1 m above water level in adjacent creek. 3 subsamples.	*Phytophthora multivora*
PR170628-STP09	*Baccharis pilularis, Elymus triticoides, Artemisia californica*	In drainage that runs past STP07 and 08. below pedestrian footbridge, Stile Ranch trail. Dieback about 50% of BAPI, some dead branches and interior thinning of canopy. ARCA looks fine. Sample root density low, mostly *Elymus* roots. Soil slightly moist, sandy clay loam. Inundated at high flow. 3 subsamples.	*Phytophthora inundata*
PR170628-STP10	*Eleocharis, Q. lobata, A. douglasiana, Toxicodendron diversilobum*	In drainage over first pedestrian footbridge, Stile Ranch trail, downslope from IBM facility and old orchard area. Thinning in QULO, ARDO spindly. Sample root density high, few oak roots. Soil dry, hard clay. Inundated at high flow. 4 subsamples.	*Phytophthora cryptogea* complex

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR170628-STP11	*U. californica, Q. agrifolia, Q. lobata, T. diversilobum*	Along drainage farther downslope from STP10. Large oaks, QUAG about 40 cm DBH with some dieback, QULO about 50 cm DBH, thinning and declining. Understory bay and poison oak look fine. Sample root density very high. Soil dry, hard clay. Inundated at high flow, currently 0.5 to 3 m above water level in adjacent creek. 4 subsamples.	no *Phytophthora*
PR170628-STP12	*Q. lobata, Rosa californica, A. douglasiana, Sambucus nigra* ssp. *caerulea, Cynara cardunculus*	In drainage on either side of trail, QULO of 25 and 13 cm DBH, both with some thinning. *Sambucus* also looks in poor condition. Sample root density moderate. Soil moist, inundated at high flow, drainage is muddy but no standing water. Soil temp=69F. 3 subsamples.	*Phytophthora inundata, Phytophthora pseudocryptogea*
PR170628-STP13	*Q. lobata, Rosa californica, A. douglasiana, Sambucus nigra* ssp. *caerulea, Cynara cardunculus*	In same drainage but sample collected higher on sides of drainage where soil is dry. Sample root density- moderate, mostly ROCA roots. Soil- dry and hard, clay. Soil temp=73F. 3 subsamples.	no *Phytophthora*

Table 3.3.8-2. DNA sequencing details for *Phytophthora* isolates recovered during 10 April and 28 June 2017 sampling at Santa Teresa County Park*. .* GenBank=National Center for Biotechnology Information (NCBI), *PhytID=Phytophthora*-ID.org; both maintain databases of *Phytophthora* genomic sequences.

Isolate number	PDR number	Identification	Sequencing result details
PR170410-STP03-1	MV6P06578746-1	*Phytophthora* taxon *europaea*-like	*Phytophthora europaea* ITS: 821/823 (99%) to ex-type GenBank MG865488; 820/825 (99%) to ex-type GenBank NR_147861.1
PR170410-STP04-1	MV6P06578746-2	*Phytophthora chlamydospora*	*Phytophthora chlamydospora* ITS: 100% (824/824)
PR170628-STP08-5	MV6P06578755	*Phytophthora multivora*	*Phytophthora multivora* ITS: 100% (766/766)
PR170628-STP09-5	MV6P06578755	*Phytophthora inundata*	*Phytophthora inundata* ITS: 100% (811/811) to ex-type P246b GenBank AF266791.1
PR170628-STP10-1	MV6P06578755	*Phytophthora cryptogea* complex	*Phytophthora cryptogea* ITS: strain TARI 90130 GenBank GU111631 100% (807/807). Ex-type strain GenBank MG865483 CPHST BL 16 (798/808)
PR170628-STP12-1	MV6P06578755	*Phytophthora inundata*	*Phytophthora inundata* ITS: 100% (809/809)) to ex-type P246b GenBank AF266791.1
PR170628-STP12-2	MV6P06578755	*Phytophthora inundata*	*Phytophthora inundata* ITS: 100% (811/811)) to ex-type P246b GenBank AF266791.1
PR170628-STP12-3	MV6P06578755	*Phytophthora pseudocryptogea*	*Phytophthora pseudocryptogea* ITS: 99% (762/763) to ex-type strain SUC620 GenBank KP288373.1

3.3.9. Sierra Vista Open Space Preserve

We collected four root/soil samples at Sierra Vista Open Space Preserve on 15 January 2018. We had intended to sample the chaparral area along the Calaveras Fault Trail (Figure 3.3.9-2, right), but the road/trail access to that area was closed. We detected *Phytophthora* in three of the four sites we sampled, mostly along drainages, within a small area in the reserve boundary (Figure 3.3.9-1, 3.3.9-2). Three different terrestrial *Phytophthora* species, *P. cactorum, P. crassamura*, and *P. pseudocryptogea*, were detected (Table 3.3.9-1), a relatively high diversity over such a small area. The three *Phytophthora* positive sites were in seasonally wet areas along separate drainages that extended to and beyond Sierra Road in the upslope direction. The source(s) of the *Phytophthora* infestations at this site are not obvious. They could be related to developed parcels upslope from the road, from contamination along the road, movement of contamination within or from beyond the parcel via livestock, and/or historical land uses or visitor activities that were not obvious. Further sampling of this preserve would be needed to determine whether *Phytophthora* is also present in other habitat areas, including sites downstream from the infested areas. One mitigating factor at this site are the large largely host-free grassland gaps between infested areas at SV02 and SV03 and susceptible vegetation downslope, which would slow unassisted *Phytophthora* spread from these areas.

Figure 3.3.9-1. Image of sample points and baiting results for 15 January 2018 sampling at Sierra Vista Open Space Preserve.

Figure 3.3.9-2. Sample points at Sierra Vista Open Space Preserve collected 15 January 2018. Yellow icons represent samples from which no *Phytophthora* was detected.

Table 3.3.9-1. Samples collected at Sierra Vista Open Space Preserve on 15 January 2018.

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR180115 -SV01	*Sambucus nigra* ssp. *caerulea,* grass	In alluvial plain, near intersection Sierra Vista Trail and Upper Calaveras Fault Trail. Very old SAME with 3 decadent trunks, individual trunks of DBH 20 to 25 cm, plant height 4-5 m. Internode growth short, no shallow roots, roots found starting at 15-20 cm in soil profile. Sample root density- moderate, soil moisture- moist, sandy clay loam. 4 subsamples. Soil temperature 55.	no *Phytophthora*
PR180115 -SV02	*Quercus lobata*, grass	Valley oak grove in drainage downslope from Sierra road, DBH of oaks 35 to 55 cm or larger. Oaks look ok. Roots found starting at 20 cm deep in soil profile. Sample root density- moderate, soil moisture- moist, rocky sandy clay loam. 4 subsamples. Soil temperature 56.	*Phytophthora pseudocryptogea*
PR180115 -SV03	*Platanus racemosa, Artemisia douglasiana, Scrophularia californica*	*Platanus* grove in ravine to south of ravine sampled for SV02. Sycamores look ok, one old trunk with wood decay, large trees, DBH range 0.7 to 1.1. m approx. Free standing water in bottom of ravine, looks like cattle tank may have been located here that washed out or was breached sometime in past. Plentiful shallow roots. Sample root density- high, soil moisture- moist to wet, loam. 3 subsamples. Soil temperature 57.	*Phytophthora cactorum*

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR180115-SV04	*Quercus lobata, Quercus agrifolia*	Located along ravine downstream from the Sierra Vista Trail bridge. Both trees show thinning. DBH of QULO 1 m, QUAG about 0.7 m DBH. Plentiful shallow roots. Sample root density- high, soil moisture- moist loam. 4 subsamples. Soil temperature 58.	*Phytophthora crassamura*

Table 3.3.9-2. DNA sequencing details for *Phytophthora* isolates recovered during 15 Jan 2018 sampling at Sierra Vista Open Space Preserve. GenBank=National Center for Biotechnology Information (NCBI), *PhytID=Phytophthora*-ID.org; both maintain databases of *Phytophthora* genomic sequences.

Isolate number	PDR number	Identification	Sequencing result details
PR180115-SV02-1	MV6P06578771-2	*Phytophthora pseudocryptogea*	*Phytophthora pseudocryptogea* ITS: GenBank ex-type MG865572 (804/804); PhytID (740/740)
PR180115-SV02-2	MV6P06578771-3	*Phytophthora pseudocryptogea*	*Phytophthora pseudocryptogea* ITS: GenBank ex-type MG865572 (804/804); PhytID (740/740)
PR180115-SV03-1	MV6P06578771-4	*Phytophthora cactorum*	*Phytophthora cactorum* ITS: GenBank (800/800) PhytID (735/735)
PR180115-SV04-1	MV6P06578771-5	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: GenBank (819/819) PhytID (757/757)

3.3.10. Pacheco Creek Reserve

We collected 2 water samples and 8 soil/root samples from the SCVHA Pacheco Creek Reserve on 17 May 2017. This site was considered to have an elevated risk of having *Phytophthora* contamination because of previous plantings of nursery stock at this site. Terah Donovan provided a copy of a March 1997 monitoring report related to a previous Caltrans planting at this location. According to the report, a total of 107 1-foot-tall *Quercus lobata* and *Q. agrifolia* were planted in December 1996. Some of these would have been planted in areas between our sampling points PP01 and PP10, and PP01 and PP06 (Figure 3.3.10-1). We had this report with us and referred to the planting map during our visit. We did not see evidence of surviving oaks from the December 1996 planting in these areas and did not encounter definitive remnants of planted material in our samples. *Phytophthora* was not detected in our samples from these previously planted areas.

Surviving *Quercus lobata* transplants and a grouping of four surviving *Prunus ilicifolia* transplants were located at our sample points PP08 and PP09 (Figure 3.3.10-1). We observed old PVC irrigation lines around these plants and a synthetic weed mat was found at the base of one of the sampled *Q. lobata*. We could not determine whether the oaks are survivors from the 1996 planting or date to an earlier planting. *Phytophthora cactorum* was recovered from roots of the planted *P. ilicifolia*, but no *Phytophthora* species were recovered from the sampled oaks.

After our visit, we obtained a copy of a December 1996 Monitoring Report for the project from Matt Quinn. That report includes an annotated oblique aerial photo diagram (Figure 5 in the report) that points out an area ("D") with initially successful sycamore plantings, and an area ("E") where mitigation plantings had "above average growth and vigor for the site". However, we did not notice sycamores in area "D" during our visit. We did not specifically look in area "E" due to heavy growth of *Conium maculatum* and *Cirsium vulgare*, but neither site observations or aerial imagery indicated any significant woody plant cover in this area.

No *Phytophthora* species were detected from the two water samples. However, three clade 6 *Phytophthora* species commonly found in water, *P. gonapodyides*, a strain in the *P. lacustris* complex, and *P. chlamydospora*, were detected in root/soil samples from plants that would have been inundated at high creek flows (PP04 and PP07, Tables 3.3.10-1, 3.3.10-2).

Figure 3.3.10-1. Samples collected at Pacheco Creek Reserve on 17 May 2017. Pink icons represent *Phytophthora* positive samples, yellow icons represent *Phytophthora* negative samples. Yellow lines indicate the reserve boundaries. Sample details and identifications are shown in Tables 3.3.10-1 and 3.3.10-2.

Table 3.3.10-1. Samples collected at Pacheco Creek Reserve on 17 May 2017.

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR170517 -PP01	*Quercus agrifolia, Sambucus nigra* ssp. *caerulea, Carduus pycnocephalus, Bromus diandrus*	Oaks and elderberry appear to be natural, no real symptoms, possibly in flood zone, no sign of previous plantings that were supposed to be in this area according to the planting map. Sample root density high, soil dry loam, 4 subsamples, soil temp in shade at 10 cm 57F.	no *Phytophthora*
PR170517 -PP02	*Grindelia squarrosa, Vulpia myuros,* clover, *Lupinus*	No real symptoms, except for gumweed, vegetation beginning to dry up. Possibly in overflow zone of side channel. No sign of former oak planting supposed to be in this area according to the planting map. Sample root density low, soil dry, rocky, stony, hard to dig.	no *Phytophthora*
PR170517 -PP03	water	Pacheco Creek, water depth about 80 cm, flow rate low, clear, greenish, no algae, bottom sandy, some organic matter, streamside vegetation includes sandbar willow, mulefat, *Rumex*, cattail. 4 subsamples collected within 1 m of bank, water temperature ~ 62F.	no *Phytophthora*

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR170517 -PP04	*Platanus racemosa, Conium maculatum, Bromus diandrus, Cirsium vulgare*	The mature sycamore looks has been hit hard by anthracnose, extreme dieback, other species occur densely under the canopy and nearby and look ok, sampled in root zone of sycamore under canopy, few roots in upper 10 cm of soil, sycamore roots found at depth of 20-30 cm. Probably was in the flood zone, Sample root density- moderate, soil- dry silt, very light, very light and easy to dig, 3 subsamples, soil toil temp 64F at 10 cm.	*Phytophthora gonapodyides*
PR170517 -PP05	*Grindelia squarrosa, Avena fatua,* grass, clover	Grass and forbs drying up, roots in sample mostly gumweed and forbs. One hole contained metal, wooden stake remnants. No sign of former oak planting that according to map should be in this area. Sample root density- moderate, soil- dry silty loam, 4 subsamples, soil temperature 73F at 10 cm.	no *Phytophthora*
PR170517 -PP06	water	Pacheco Creek, water depth about 20 cm, flow rate low, clear, greenish, long green algae, bottom rocks and silt, streamside vegetation includes *Salix* (*laevigata*?), mulefat, cattail. 4 subsamples collected about 3 m from bank, water temperature 62F.	no *Phytophthora*
PR170517 -PP07	*Artemisia douglasiana*	Plant collected in flood zone and river braided area, was partially buried in sand, roots look ok. Sample root density high, soil dry sand, 3 subsamples. Soil temperature 74F at 20 cm.	*Phytophthora chlamydospora, P. gonapodyides, P. lacustris* complex
PR170517 -PP08	*Quercus lobata*	Composite of 2 worst looking planted oaks in this area, have twig dieback, appears to be 6 planted valley oaks in this area, weed mat around one and irrigation pipe near another. Sample root density moderate, soil dry silty loam.	no *Phytophthora*
PR170517 -PP09	*Prunus ilicifolia*	4 planted plants, are very stunted but otherwise look ok, have metal tags, irrigation lines nearby, in adjacent freeway right of way are toyon (presumably planted) and buckwheat. Sample root density high, soil dry, silty loam, 4 subsamples, one for each plant.	*Phytophthora cactorum*
PR170517 -PP10	*Quercus lobata*	Large natural tree with DBH about 1.25 m, looks ok. Lot of bull thistle and ripgut in understory, one dead elderberry and a live elderberry opposite sides of trunk, old metal pieces, pipe, rope in rootzone. Sample root density low, soil dry, silty, rocky, gravelly.	no *Phytophthora*

Table 3.3.10-2. DNA sequencing details for *Phytophthora* isolates recovered during 10 April 2017 sampling at Pacheco Creek Reserve. GenBank=National Center for Biotechnology Information (NCBI), *PhytID=Phytophthora*-ID.org; both maintain databases of *Phytophthora* genomic sequences.

Isolate number	PDR number	Identification	Sequencing result details
PR170517-PP04-1	MV6P06578747-1	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: 100% (811/811)
PR170517-PP07-1	MV6P06578747-2	*Phytophthora chlamydospora*	*Phytophthora chlamydospora* ITS: 100% (813/813)
PR170517-PP07-2	MV6P06578747-3	*Phytophthora gonapodyides*	*Phytophthora gonapodyides* ITS: 100% (804/804)
PR170517-PP07-4	MV6P06578747-4	*Phytophthora lacustris* complex	*Phytophthora lacustris* ITS: 800/803(99%) to type GenBank JQ626605.1
PR170517-PP09-1	MV6P06578747-5	*Phytophthora cactorum*	*Phytophthora cactorum* ITS: 100% (785/785)

3.3.11. Rancho Cañada de Oro Open Space Preserve

We collected two soil/oak samples from a localized area in blue oak woodland on 28 June 2017 (Table 3.3.11-1, Figure 3.3.11-3). The blue oaks in the sampled area were particularly unthrifty looking, with evidence of chronic thinning and dieback (Figure 3.3.11-1). We recovered *P. cambivora* from one of the samples (Tables 3.3.11-1, 3.3.11-2).

We returned to Rancho Cañada de Oro Open Space Preserve on 6 December 2017 to collect more samples in blue oak and valley oak woodland types. We collected 7 additional soil samples at this time (Table 3.3.11-1). We also collected two additional samples 29 December 2017 in connection with sampling in the adjacent portion of Calero Park (Table 3.3.11-1).

Additional *Phytophthora* species were detected in our December 2017 sampling. *P*. taxon agrifolia and *P. crassamura* were detected under two valley oaks (RO07) in an old clearing that had ruins of a structure at one end. A drainage ditch had been cut across the clearing near the trees, and the area was also crossed by a dirt ranch road. This area and its surroundings were also grazed. This was only our second detection of *P*. taxon agrifolia at the time.

One other unusual detection at this location was *Phytophthora* taxon ohioensis-like under valley oaks in a low area close to a creek north of Casa Loma Road (Figure 3.3.11-3). The area had ruins of a cattle chute and fencing, suggesting that it was previously used to concentrate and load livestock (Figure 3.3.11-2, top). The detection was at the intersection of the main road/trail and another one leading into the chaparral upslope where stockpiles of earth materials had been placed (Figure 3.3.11-2, bottom).

In related sampling, *P. cambivora* was detected in under a valley oak within a former walnut orchard in Calero Park (CP28) at a point about 1.2 km to the northeast of RO01. There are no direct connections between CP28 and RO01, so direct movement between these two points is unlikely. However, other infested former orchards in the local area might be the source of the RO01 infestation. Infested soil or plant debris may have been transported to the RO01 area on equipment, vehicles, footwear, livestock, or other animals. If this is the case, it is likely that other undetected *P. cambivora* infestations are present in this area.

Figure 3.3.11-1. Blue oaks (*Quercus douglasii*) sampled at Rancho Cañada de Oro Open Space Preserve on 28 June 2017 showed extreme canopy thinning and dieback. *Phytophthora cambivora* was baited from one of two samples collected under these trees.

Figure 3.3.11-2. Top - *Phytophthora* taxon ohioensis-like was baited from soil and roots collected on 29 December 2017 beneath the two large valley oaks on either side of this trail at Rancho Cañada de Oro Open Space Preserve. Remnants of a cattle chute are visible next to the oak at the right. Bottom – Photo taken from the opposite direction shows gated road to chaparral area and piles of earth materials near one of the sampled trees. Photo date 29 Dec 2017.

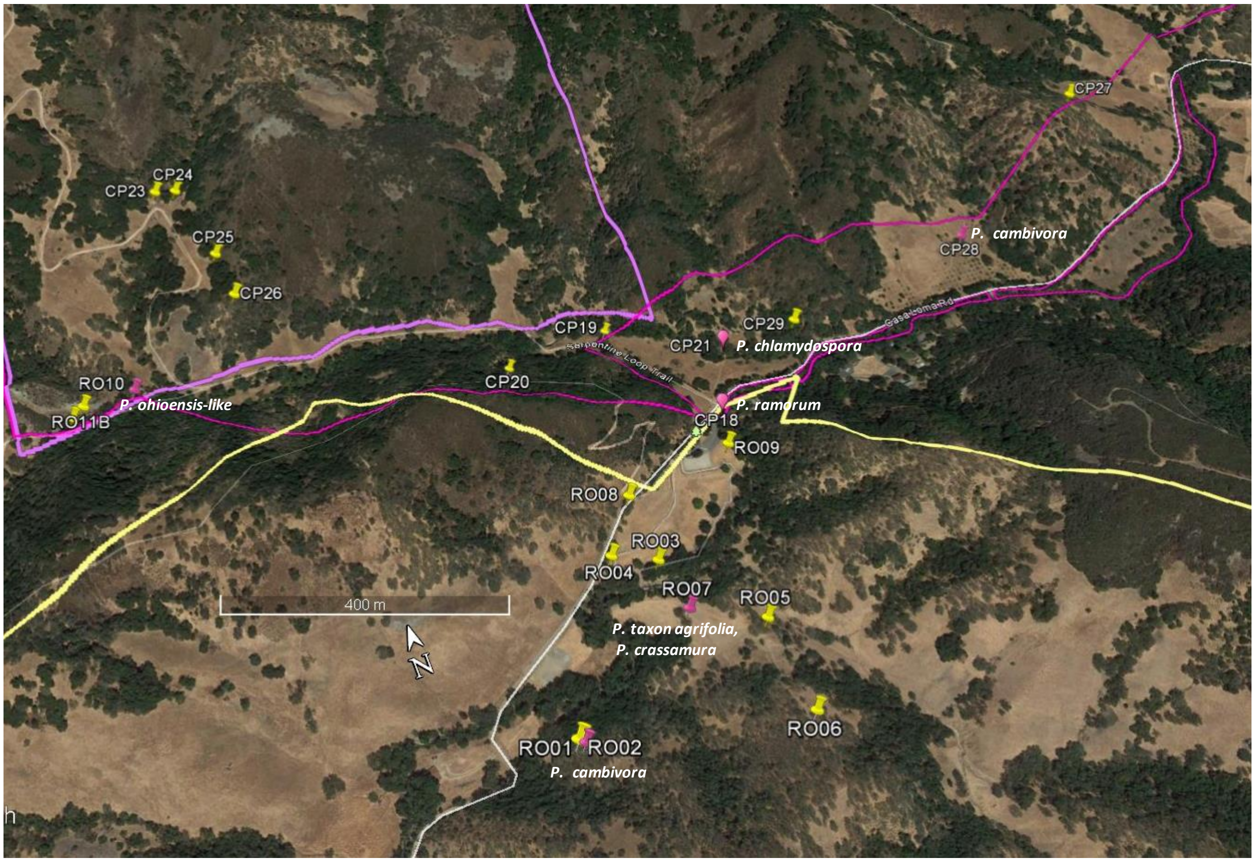


Figure 3.3.11-3. June and December 2017 sampling points at Rancho Cañada de Oro Open Space Preserve. Pink icons represent samples with *Phytophthora* detections, yellow icons represent samples with no *Phytophthora* detection. Drop-shaped icons represent water samples. Sample details and identifications are shown in Tables 3.3.11-1 and 3.3.11-2. Sample points from the south portion of Calero County Park are also visible in this image.

Table 3.3.11-1. Samples collected at Rancho Cañada de Oro Open Space Preserve on 28 June, 6 December, and 29 December 2017.

Sample number	Vegetation sampled	Sample Notes	*Phytophthora* species detected
PR170628 -RO01	*Quercus douglasii, Grossularia, Rhamnus crocea*	Blue oaks look particularly shabby, with severe canopy dieback and thinning, epicormic sprouting. Shrubs are small but otherwise ok. Sample root density- low, soil- dry hard clay loam. 3 subsamples.	*Phytophthora*, *cambivora*
PR170628 -RO02	*Q. douglasii, Grossularia*, forbs, grass	Duplicate sample in same area as RO01. Sample root density- low, soil- dry hard clay loam. 4 subsamples.	no *Phytophthora*
PR171206 -RO03	*Quercus agrifolia,* grass, thistles	Generally healthy mature coast live oaks, some a bit thin, DBH 0.6 to 1 m, between paved walking path and fence, about 35 m from creek. Sampling in a shallow swale. Forbs just starting to sprout in understory. QUAG roots abundant in upper soil profile. Sample root density: very high. Soil: loam, moist, not sticky. temperature 50 F. 4 subsamples.	no *Phytophthora*
PR171206 -RO04	*Quercus lobata,* grass	Three mature valley oaks, low vigor, short internodes, look somewhat water stressed, leafy mistletoe in canopies, DBH 0.15, 0.6, and 0.8 m, south of paved walking path. Sample root density: high. Soil: clay loam, moist, not sticky. Soil temperature 49 F. 4 subsamples.	no *Phytophthora*
PR171206 -RO05	*Quercus douglasii, Quercus lobata*	Sample upslope of fence and cattle trail, trees appear thin and water stressed, leafy mistletoe in canopies, sampled 0.3 m DBH QULO and 0.5 m DBH QUDO. Sample root density: high. Soil: light texture, slightly moist, 10-15cm soil over partially decomposed parent material. 4 subsamples.	no *Phytophthora*
PR171206 -RO06	*Quercus douglasii*	Three mature QUDO, 0.2, 0.35, and 0.5 m DBH, low vigor, short internodes, thinning, on either side dirt road, grazed area, few shrubs, none in sample. Sample root density: high. Soil: rocky loam, slightly moist. 4 subsamples.	no *Phytophthora*
PR171206 -RO07	*Quercus lobata*	QULO 0.9 and 0.7 m DBH beside ditch/swale that crosses the slightly sloping area. Larger tree thinning and leafy mistletoe, few roots found, smaller tree still hasn't defoliated, many roots found. Sample root density: high. Soil: clay loam, rocky, slightly moist, soil temperature 46 F. 5 subsamples.	*Phytophthora* taxon agrifolia, *P crassamura, Pythium dissotocum*
PR171206 -RO08	*Quercus lobata, Quercus douglasii*	Oaks on lower edge road shoulder towards walking path, long internodes, trailing outer canopy branches. QULO 0.7m, and 0.9m DBH, QUDO 0.4m DBH. Sample root density: high. Soil: clay loam, moist. 5 subsamples.	no *Phytophthora*
PR171206 -RO09	*Quercus lobata*	Transplants about 5 cm DBH, look ok. Root crowns are buried about 20-30 cm deep, could not reach roots, perlite seen about 25 cm deep on one. Sample root density: none. Soil: clayey, moist. 2 subsamples.	no *Phytophthora*
PR171229 -RO10	*Quercus lobata, Toxicodendron diversilobum, Frangula californica*	In flat area used for cattle corral in past surrounded by seasonal drainages on two sides. Samples collected around two large valley oaks, DBH about 1.2m, current internode growth short. Soil: slightly moist, granulated clay loam. Sample root density: high. Soil temperature 47 F. 4 subsamples.	*Phytophthora* sp. ohioensis-like
PR171229 -RO11	*Arctostaphylos glauca, Heteromeles arbutifolia*	Serpentine chaparral between on slope between two roads. Thick duff layer about 10 cm or more. Toyon and manzanita have varying amounts of dieback. Soil: slightly moist, rocky clay loam. Sample root density: moderate. Soil temperature 49 F. 4 subsamples.	no *Phytophthora*

Table 3.3.11-2. DNA sequencing details for *Phytophthora* isolates from 28 June 2017 sampling at Rancho Cañada de Oro Open Space Preserve. GenBank=National Center for Biotechnology Information (NCBI), *PhytID=Phytophthora*-ID.org; both maintain databases of *Phytophthora* genomic sequences.

Isolate number	PDR number	Identification	Sequencing result details
PR170628-RO01	MV6P06578756	*Phytophthora*, *cambivora*	*Phytophthora cambivora* ITS: 100% (839/839).
PR171206-RO07-6A	MV6P06578764-1	*Phytophthora* taxon agrifolia	100% match to P. taxon agrifolia, an undescribed species from San Mateo county. *Phytophthora foliorum* ITS GenBank (756/815).
PR171206-RO07-6D	MV6P06578764-2	*Pythium dissotocum*[1]	*Pythium dissotocum* ITS: GenBank (786/786)
PR171206-RO07-9	MV6P06578764-3	*Phytophthora crassamura*	*Phytophthora crassamura* ITS: GenBank (806/806) PhytID (806/806)
PR171229-RO10	MV6P06578771-1	*Phytophthora* taxon ohioensis-like	*Phytophthora* sp. ohioensis ITS: ST18-37 GenBank EU196370 (809/810) and PhytID HQ261710.1 (746/747)

[1]This culture was sent to CDFA for sequencing because of its initial similarity to *Phytophthora*. *Pythium* is a closely related genus. *Pythium* species were often encountered during this study.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Validation of the risk model for sampling and monitoring

4.1.1. Soil moisture regime

Sampling results were generally consistent with what we anticipated from our risk model with respect to the influence of moisture on site receptivity. *Phytophthora* species were detected in water and periodically flooded sites most frequently (Table 3.1.3). *Phytophthora* was rarely detected in well-drained upland sites, with the Anderson Lake west dam abutment being a notable exception. Across the sampled locations, the likelihood of detecting *Phytophthora* was more strongly influenced by the moisture regime at the sample site than the vegetation type (Table 4.1). In a logistic regression model (overall model $P<0.0001$) using *Phytophthora* detection as a binary outcome, the site moisture variable (dry vs. periodically flooded) was significant at $P<0.0001$ (odds ratio 11.23, 95% CI 4.33-31.0). However, a host species variable (*Quercus* only vs. shrubs without *Quercus*) and the site moisture × host species interaction were not significant (P= 0.663 and 0.423, respectively). Effects of host species are discussed further in section 4.1.2 below.

Table 4.1-1. Comparison of *Phytophthora* detection in upland versus periodically flooded sites for shrub samples versus samples containing *Quercus*.

	Dry sites[1]		**Periodically-flooded sites[2]**		**Totals**	
Host roots in sample	Number of samples	**% with *Phytophthora***	Number of samples	**% with *Phytophthora***	Number of samples	**% with *Phytophthora***
***Quercus* only or with other species**	40	**15%**	14	**57%**	54	**26%**
Shrub species[3] only without *Quercus*	71	**8%**	13	**46%**	84	**17%**
Totals	111	**11%**	27	**52%**	138	**19%**

[1]Dry sites include samples collected on hillslopes and flat/lowland positions not subject to periodic flooding.
[2]Periodically-flooded samples were collected from edges of waterbodies, along ravines/swales, or on floodplains.
[3]Shrub species included in this category include *Arctostaphylos* spp., *Artemisia californica, Baccharis pilularis, Ceanothus ferrisiae, Frangula californica,* and *Heteromeles arbutifolia.*

A different situation was observed in Anderson Lake County Park. All the *Phytophthora* detections in dry shrub-dominated sites lacking oaks were from this location: five from the Anderson Dam abutment slope (west of the dam) and one from an upland area along a trail on the south side of the lake (sample AD53, Figure 3.2.2-2). Including sampling conducted before this project, *Phytophthora* was detected in 60% (18 of 30) of the dry upland samples we have tested from the dam abutment. These samples included six *Phytophthora* species (*P. cactorum*, *P. cambivora, P. cryptogea* complex, *P. crassamura, P. megasperma* complex, and *P. syringae*).

Data from other northern California sites we have sampled, including stands of *Arctostaphylos myrtifolia* and *A. pallida* infested with *P. cinnamomi,* clearly show that *Phytophthora* infestations in native habitats do not require periodic flooding. However, our risk model indicates that periodically wet sites, especially those with woody hosts, have a higher receptivity to *Phytophthora* invasion. The preponderance of *Phytophthora* detections in periodically wet sites is consistent with this component of the risk model. Although dry habitats dominated by woody species can be invaded by *Phytophthora* species, our data suggest that such situations are currently uncommon among sites sample in and adjacent to the reserve system.

4.1.2. Presence of susceptible hosts

The risk model predicts that habitats with woody roots are more likely to become invaded by *Phytophthora* species than are habitats dominated by grasses and forbs. Except for three wetland samples collected at the edges of ponds, woody host roots were present in all root/soil samples in which *Phytophthora* species were detected (Table 3.1.2). Due to limited time and resources, we did not conduct much sampling of hosts considered to have very low risk *Phytophthora*. *Phytophthora* was not detected in three samples collected in grassland habitats that had exclusively roots of grasses and herbaceous dicots, though this is too small a sample from which to draw general conclusions. There are relatively few records of *Phytophthora* species reported as pathogens of members of the Poaceae in the scientific literature (Farr and Rossman 2018).

The risk model predicts that both shrublands and hardwood woodlands and forests are high receptivity sites, and these vegetation types were where *Phytophthora* was detected in dry sites. Because many of our samples contained a mixture of potential host roots, it is difficult to draw strong conclusions about the effects of individual host species on *Phytophthora* presence. The most common overstory trees in our sampling were oaks (*Quercus*), in both the white oak (*Q. douglasii*, *Q. lobata*) and black oak (*Q. agrifolia, Q. kelloggii*) subgenera. As shown in Table 4.1-1 and noted in the analysis above, the presence of *Quercus* roots in samples was not significantly related to the detection of *Phytophthora* compared to samples with only shrub roots. While certain host species may be more likely to be affected by specific *Phytophthora* taxa, such associations are not clear from our limited number of *Phytophthora* infested sites. For the purposes of modeling risk to a range of introduced *Phytophthora* taxa, both hardwood trees and shrubs should be considered highly susceptible to invasion.

4.1.3. Introduction risk pathways

Most of the *Phytophthora* infestations we detected were associated with routes of pathogen introduction identified in our risk model. *Phytophthora* was associated with nursery stock planted for habitat restoration (Anderson Dam abutment) or landscaping (Joseph Grant Park, Pacheco Creek Reserve), downslope from landscaping (Santa Teresa), former orchard land (Calero Park - south), a homestead/agriculture site (Rancho Cañada de Oro). Infestations were also detected in high-traffic disturbed areas (Coyote Lake) and along trails, such as the detection of *P. crassamura* at an upland site east of Anderson Dam (AD53) directly adjacent to a heavily-used trail junction. The common detections of clade 6 *Phytophthora* species in water and periodically inundated areas was also anticipated by the risk model.

4.1.4. Model limitations

Although the risk-modelling approach we followed worked well for this project, application of the model for any given site was subject to various limitations. GIS-based data layers and maps were very useful for selecting potential sampling areas, but additional in-field observations were needed to evaluate risk factors. The vegetation mapping layer was too coarse to provide reliable information on the location of priority species in some locations, such as stands of blue or valley oaks (sensitive land cover types) within polygons mapped as coast live oak forest and woodland. Similarly, stands of mixed serpentine chaparral (high receptivity) were not differentiated within areas mapped as serpentine bunchgrass grassland or serpentine rock outcrop/barrens (both low receptivity). We also found extensive stands of valley oak woodland misclassified as blue oak woodland (Joseph Grant Park). Where vegetation mapping data are inaccurate, both *Phytophthora* risk and sampling priority may be misclassified in the GIS analysis. Furthermore, field-level observations commonly revealed pathways (current livestock use, nursery stock plantings) and site history factors (prior land uses and disturbances) related to *Phytophthora* introduction risk that could not be identified in the GIS analysis. Finally, data on plant symptoms were not available in the GIS layers and could not be reliably visualized in aerial imagery, so direct field observations were critical to determining where sampling should occur.

Even with GIS data and field observations, many past land use and disturbance events remain unknown. For instance, at one site (RO07), *Phytophthora* taxon agrifolia and *P. crassamura* were recovered from beneath two valley oaks in an old clearing. A constructed ditch passed through the clearing near the trees and remnants of a structure were seen at the edge of the clearing uphill from the trees. These observations clearly indicated a prior land use, but without additional historical information, it is not possible to infer whether the *Phytophthora* introductions were associated with previous plantings, the construction of the ditch, recent cattle use of the area, or other factors. With only general information about the disturbances at the site, the current model would suggest that the *Phytophthora* risk was elevated to some degree but would not identify the site as having a high risk. The GIS analysis alone would not have identified this site as a sampling priority.

The *Phytophthora* detections at Anderson Lake County Park provide additional examples of the importance of transient events. The initial *Phytophthora* detections on the dam abutment were made before we had any knowledge of the past restoration plantings in the area. No planting location records were available, but we were able to locate the planting areas based on recollections of a SCVWD staff member. We were then able to find planting basins and discarded containers to confirm the locations. Without the information about the planting, it would have been difficult or impossible to identify the source of this infestation.

Also, we detected an unusual diversity of *Phytophthora* species among *Ceanothus ferrisiae* and other woody species along the reservoir's high-water line. The plants were in a zone that was a dry slope for many successive years because seismic restrictions have limited the reservoir level to 60% capacity or less since about 2009. After record rains in early 2017, this zone was at the water's edge or shallowly flooded for a short period. Plants in this area effectively served as in-situ whole plant baits for *Phytophthora*. Although the presence of clade 6 species *P. gonapodyides* and *P. chlamydospora* in these plants was not unexpected, the prevalence of *P. crassamura* and occurrences of the unusual taxa *P.*

asparagi and *P*. taxon agrifolia were initially somewhat surprising. However, these detections were more readily explained when we identified a large potential source of diverse *Phytophthora* species about 1 to 2 km from the high-water line *Phytophthora* detections. Runoff from the landscaped development on the west shore of the lake's south arm (Holiday Lake Estates) flowing into the lake during the heavy winter rainfall of 2017 would be expected to contain a potentially diverse array of *Phytophthora* inoculum. This inoculum, as spores or infected debris, would have been channeled past the detection site as the water moved toward the outflow.

Although this mode of inoculum movement is consistent with the risk model, it could not have occurred until the unusual weather conditions that created the transient flooding and flow of inoculum into the area. While we were able to observe the events that were associated with this introduction, in other sites localized disturbance or events that could account for *Phytophthora* introductions may not be observed or recorded. Hence, the few *Phytophthora* introductions that are not now obviously associated with clear risk factors could have been contaminated through processes discussed in the risk model, even if the specific processes are not currently identifiable.

Furthermore, changed future conditions could increase the risk of *Phytophthora* introduction and spread beyond currently-identified levels. For instance, if water levels in Anderson Lake are raised more frequently in the future after seismic issues are corrected, plant populations subjected to more frequent inundation events or higher soil moisture levels would have a greater risk of infection and disease spread than they do at present. Changes in moisture regimes related to diversions, dams, or grading, installation of additional nursery stock plantings, trail and road construction and other future activities can significantly change risks related to *Phytophthora* introduction and spread and need to be accounted for in the management of the reserve system.

4.2. Recommendations for sampling and monitoring

1. The methods used in this study, including the initial GIS analysis, provide a good template for planning and prioritizing sampling over large areas, such as the entire reserve system or a given large reserve. The analysis would be improved with more accurate vegetation mapping, information on locations of plantings of nursery stock for restoration or landscaping, and additional data on land use history, such as the location of former agricultural fields or orchards, homesteads, and the like.
2. In-field observations by experienced personnel are critical for identifying symptomatic vegetation and interpreting landscape patterns that suggest areas with elevated risk. These observations are needed to efficiently conduct sampling to detect and delineate *Phytophthora* infestations.
3. Detection efficiency varies seasonally, so surveys should be timed to optimize detection based on site conditions. Data we have collected in repeat sampling indicates that *Phytophthora* is more likely to be detected when the soil has not been dry for an extended period. In general, soil moisture is less favorable for sampling from mid to late summer until the first significant fall rains. Because soil moisture is affected by weather, site evapotranspiration and local hydrology, optimal date range that is will vary by site and current season rainfall. While *Phytophthora* can still be detected under suboptimal conditions, negative results need to be interpreted with more caution. When sampling outside of optimal conditions, sampling intensity should be increased and follow-up sampling under more optimal conditions should be considered where negative results are obtained, especially in high risk sites.

4. Once infested points have been detected, additional sampling will typically be needed to delineate the extent of infestations. For delineation surveys, additional sampling should be conducted upslope and downslope from identified infestations and along local pathways of secondary spread, such as trails, roads, and watercourses. Initial sampling should concentrate on symptomatic vegetation, but asymptomatic plants that are likely hosts should also be sampled to detect areas where the pathogen may have spread but not yet caused obvious symptoms.
5. The same general techniques apply to monitoring spread from delineated infestations. *Phytophthora* infestations can spread naturally within stands of host vegetation, especially where root systems overlap substantially. Spread is unlikely to occur into nonhost vegetation such as annual grassland, but may cross over nonhost gaps via flowing water or by assisted spread via soil movement. Monitoring of *Phytophthora* spread from known infested areas should emphasize areas downslope and downstream from the infestation, and along high-risk pathways that traverse the infested area.
6. Land managers should understand that symptom development many not occur for many years after an introduction and may only appear after environmental conditions that favor disease and symptom expression (e.g., extended wet periods, preceded, or followed by drought). Hence, Phytophthora root rot can be associated with either long-term plant decline or sudden changes in plant health, but infested areas may not show apparent symptoms for extended periods of time.

In most areas, we lack information needed to determine when a given infestation may have been initiated. The association of the *Phytophthora* infestation on the Anderson Dam abutment is a rare exception to this pattern, because the date and locations of the plantings that most likely introduced the pathogens to the site are known. In some cases, further sampling to delineate the extent of identified infestations could provide information indicating whether the infestations are relatively recent in origin or longer-established.

4.3. Management strategies to minimize introductions of *Phytophthora* into new areas and to limit impacts in affected areas

Data from this study show that *Phytophthora* species have been introduced into most, if not all, of the NCCP reserve system preserve. The data also show that most reserves have only localized infestations and it is likely that a large majority of the area in the reserve system is not currently infested with introduced *Phytophthora* species. However, long term-management of the preserves will need to account for the reality that some areas are infested and others, including sensitive or critical habitat could become infested. Additional introductions and spread from existing infestations have the potential to adversely affect the long-terms sustainability of covered plant species such as *Ceanothus ferrisiae,* as well as plant communities that support other covered species.

Approaches and options for managing soil-borne *Phytophthora* species in natural habitats are limited. Of the general approaches, **prevention** is the most important and applies to all locations and situations. **Eradication** is only an option in infested areas that are quite limited in size. **Suppression** may apply to a variety of infested sites, but because it typically requires ongoing inputs, its use is generally limited to high value situations.

It is important to remember that *Phytophthora* species are a diverse group of microscopic plant pathogens, with well over 120 described species, and a number of apparent hybrids. These introduced pathogens have varying host ranges, temperature preferences, and other adaptations that can affect their ability to infest an area and infect vegetation. Hence, different *Phytophthora* species and even strains within species need to be considered as separate threats, much in the same way that different weed species pose different threats. For this reason, even in areas that are suspected or known to be infested with one or more *Phytophthora* species, practices that may introduce additional *Phytophthora* species or *Phytophthora* contamination from different locations should still be avoided to the degree possible. More diverse assemblages of *Phytophthora* species have greater potential to affect a wider variety of vegetation. In addition, mixed *Phytophthora* infestations provide more chances for genetic exchange that could give rise to better-adapted and more pathogenic strains. Beyond this, the more thoroughly contaminated an area becomes, the more likely it is to serve as a source of *Phytophthora* inoculum that can initiate satellite infestations.

4.3.1. Prevention

This approach includes strategies to:

1. Prevent new introductions from sources outside of the reserve.
2. Minimize secondary spread from infested areas within the reserve

Once they are established, *Phytophthora* infestations continue to spread through root-to-root contact and via ponded or flowing water. It is therefore critical to prevent the initial introduction of *Phytophthora* species into habitat areas. Furthermore, activities related to use and management of reserves and adjoining areas can serve to spread *Phytophthora* through the movement of infested soil, water, or plant material. The risk of introducing or spreading *Phytophthora* can be minimized by recognizing contamination risk pathways and following appropriate practices that avoid risks. The practices listed below include many of those that may apply to management activities in the reserve system, but may not constitute a complete list. For activities and situations not covered below, the risk model can be used to assess the level of risk posed. Consult with a qualified plant pathologist knowledgeable about soil-borne *Phytophthora* species in wildlands to identify additional practices to minimize risks associated with activities and situations not discussed below.

Preventing new introductions

Planting contaminated nursery stock probably poses the greatest risk for introducing new *Phytophthora* species and strains to the reserve system. However, these pathogens can also be introduced via several other pathways. **For restoration or other plantings in reserves, at gateways that connect with preserves (e.g., trailheads, parking areas), or sites that are upslope or upstream from reserve areas, the following practices should be observed to minimize the risk of new introductions.**

1. **Use minimum-risk restoration techniques whenever possible for habitat restoration.**

These include favoring and recruiting natural regeneration (e.g., by reducing grazing intensity, providing protection against various herbivores, controlling competing vegetation); direct seeding and on-site vegetative propagation with clean materials. Seed and other plant propagules should be collected and handled following guidelines in the Phytophthora Working Group or California Native Plant Society Phytophthora BMPs (PWG 2016, CNPS 2016).

2. **Prohibit the use of conventionally-produced nursery stock, which has a high likelihood of being infected with *Phytophthora*.**

Testing cannot guarantee that plant material produced under non-phytosanitary conditions will be free of *Phytophthora* due to both technical issues (test sensitivity, adequate sampling) and the time and costs involved for valid individual plant tests. Nursery stock that is free of *Phytophthora* to the maximum extent practicable needs to be produced under conditions that exclude *Phytophthora*.

3. **If nursery stock is needed, use only material produced under effective clean production BMPs to minimize *Phytophthora* risk.**

BMPs that meet these criteria have been developed for the Phytophthoras in Native Habitats Work Group (see calphytos.org) and the California Native Plant Society (CNPS.org). A generalized version of the BMPs we developed for CNPS is available at http://phytosphere.com/BMPsnursery/Index.htm. Other nursery BMPs have been developed, but many of these do not address important risk factors and are not adequate to produce plants that have a minimum likelihood of *Phytophthora* contamination.

4. **Require that all tools, equipment, and vehicles brought into preserves are free of soil and plant debris that could be contaminated with *Phytophthora*.**

Thorough cleaning of wearables, tools, equipment, and vehicles will typically remove *Phytophthora* contamination. If items have been thoroughly cleaned to remove visible deposits of soil and has been allowed to dry, the risk of introducing these pathogens will be minimal. Treatment with sanitizing agents (e.g., isopropyl alcohol or sodium hypochlorite solutions) is usually only necessary for heavily contaminated items or for treating items with surface films of contaminated water. Pressure washing can be used for most vehicles, grading equipment, and hand tools. Compressed air can be used to help blow debris and soil out of tools and equipment such as chainsaws and chippers that cannot be washed. All cleaning should occur before items are brought into sensitive areas. Additional details on sanitation of tools and equipment can be found in Swiecki and Bernhardt (2018) and Phytophthoras in Native Habitats Work Group (2016a, 2016b).

5. **Require that plant products used in reserves (e.g., rootwads used for riparian restoration, raw logs, chipped material, straw wattles) be free of *Phytophthora* contamination.**

All clean materials should be handled to prevent subsequent contamination with soil, contaminated water, or plant debris. Innately clean materials should be used preferentially where possible. These are materials that are free of *Phytophthora* contamination due to the way that they are manufactured or processed (e.g., dimensional lumber, pressure-treated timbers, materials processed via heating). For other materials, heat treatment (via solar heating, steam or dry heat) is generally required to reduce the risk of contamination. Biological heating by composting to State of California specifications can be used for compost and mulch materials, but finished materials need to be handled only with clean equipment in a way that prevents cross contamination with unfinished compost, raw feedstocks, or soil. Many composting facilities do not handle finished compost according to appropriate phytosanitary standards.

6. **Require that imported soil, gravel, or other earth materials have a very low risk of being contaminated with *Phytophthora.***

Earth materials with some risk of *Phytophthora* contamination may be used in some specific low-risk situations where spread of contamination into habitat areas will not occur, such as deep subsurface fill (>60 cm depth) or fill under pavement or other stable nonvegetated surfaces. However, in these situations care is still needed to prevent spread of contaminated earth materials along roads or beyond the low risk area.

Soil-inhabiting *Phytophthora* spp. are primarily associated with host roots found within the upper 0.5 m of soil. Hence, low risk soils typically include those taken from host-free areas (e.g., annual grasslands) or from subsoil layers (greater than 0.5 m depth) where overlying soil has been removed and not intermixed. Because plant pathogenic *Phytophthora* spp. are commonly found in rivers and other watercourses, sand and gravel should be sourced from upland quarries where the materials are not contaminated with untreated surface waters. Alternatively, proper heat treatment can be used to eliminate *Phytophthora* from contaminated earth materials. See Section 4: Soil Import and Management in Swiecki and Bernhardt (2018) referenced above for additional details and BMPs.

7. **Require that livestock moved into preserve areas from other areas are free of soil and plant debris that could be contaminated with *Phytophthora*.**

Although some wild animals may serve to move *Phytophthora* species within infested areas, livestock present a greater risk for moving contaminated soil due to their size, weight, habits, and long-distance transport. Due to their weight, hooves of large livestock such as cattle penetrate deeper into wet soils than deer. Cattle congregate around waterbodies and muddy areas, which have a high risk of *Phytophthora* activity, so mud clinging to their hooves or fur could serve to move *Phytophthora*. Unlike resident wildlife populations, cattle are commonly moved between distant locations in vehicles. This long distance transport increases their ability to bring different *Phytophthora* species to a site. Cattle grazing has been associated with introduction of *P. austrocedri* into uninfested stands of *Austrocedrus chilensis* in Patagonia (La Manna et al 2012, 2013). Best management practices for slow-the-spread initiatives for *P. cinnamomi* in Australia include ensuring livestock hooves are clean and that they stay on clean, well-drained tracks in sensitive resource areas (McCabe and Kilgour 2008).

Cattle being brought into reserves from other locations may be sources of contamination, especially if moved directly from muddy locations. For invasive weed management, livestock may be placed in holding areas for a number of days after grazing weed-infested areas before they are allowing access to sensitive areas. Removal of soil contamination could be accomplished in conjunction with this holding period. Trailers and vehicles used to transport livestock into preserves should also be free of soil and plant debris as noted under item 4 above.

Minimize secondary spread from infested areas within preserves

Existing *Phytophthora* infestations in and near preserves can spread and expand with or without human assistance. The pathogen spreads on its own by growing through infected host roots and infecting adjacent healthy roots. This type of spread is relatively slow in upslope or cross-slope direction or in level areas, generally no more than one to a few meters per year. However, sporangia and zoospores moving with flowing water can move the pathogen tens of meters down slope in surface runoff in a single season. Inoculum that reaches a watercourse can move several kilometers downstream.

Human activities that involve intentional or unintentional soil movement can also quickly move these pathogen distances of a few meters to many kilometers. These include vehicle and foot traffic, road grading, mowing, excavation, transport of soil and soil-contaminated equipment. Use of water drafted from infested watercourses for irrigation, dust control, or other applications can also move inoculum to the sites where the water is used. The first step in reducing spread from existing infestations is recognizing when activities are occurring in known infested areas. If work will occur in infested areas, appropriate modifications in working practices can prevent spread.

Soil can also be moved by animals, such as grazing livestock and feral pigs. Managing livestock grazing parameters, exclusionary fencing, and control of pig populations can be used to minimize secondary spread of *Phytophthora* by these vectors. Although other animals may travel between infested and noninfested areas, risk associated with most of these other potential vectors is low because of the low volume of potentially contaminated material moved, as noted in the introduction of the risk model.

The following practices should be observed to minimize the risk of secondary spread of *Phytophthora* within reserves. To the degree possible, these practices should also be followed in parklands and other lands surround the preserves, especially where these adjacent areas connect with preserves via roads and trails or are upslope or upstream from reserve areas.

1. **Continue to identify and delineate *Phytophthora*-infested areas to inform management.**

The *Phytophthora* infestations identified in this project constitute a starting point for understanding and managing threats posed by *Phytophthora* pathogens in the reserve system. In many cases, further sampling to better delineate the extent of infestations will be needed to know where to apply measures designed to minimize spread. Given the number of *Phytophthora* detections in our limited sampling, it is likely that additional infestations exist within the reserve system that have not yet been detected. Adaptive management of the reserve system to minimize threats posed by *Phytophthora* will need to account for the presence of existing infestations and both assisted and unassisted expansion of infested areas. This will require periodic reassessment of infested areas to track rates and pathways of spread.

2. **Ensure that personnel involved in risk-generating activities are aware of infested and sensitive areas and BMPs that apply in those areas.**

GIS layers and other map products used in the planning of maintenance, management, and restoration activities should include information about known *Phytophthora* detections and delineations, as well as areas considered to have a high likelihood of contamination, high site receptivity, and high sensitivity due to species present. Designated staff or consultants knowledgeable about *Phytophthora* BMPs should be consulted at the planning stage of activities so that modifications can be made in advance to minimize risks. Refer to Swiecki and Bernhardt (2018) for a detailed description of implementing BMPs to preventing *Phytophthora* introduction and spread associated with common management activities.

3. **Follow BMPs to avoid unnecessary incidental and large-scale movement of infested soil and debris.**

If it is not strictly necessary to excavate or grade within an infested area, risk can be minimized by simply avoiding these activities. If activities that entail intentional or incidental soil movement are unavoidable in infested areas, follow BMPs based on the *Phytophthora* risk model (Swiecki and Bernhardt 2018). This document explicitly covers trail maintenance, construction, and soil importation, but the underlying principles in the document can be extended to cover additional activities. Guidelines available from the Phytophthoras in Native Habitats Work Group (cited in item 4 under prevention above) are much more limited in scope but cover many of the basic BMPs.

4. **Manage travel and workflow to minimize movement of contamination out of infested areas or into sensitive sites**

Where it is not possible to avoid soil-moving operations that will occur in or cross through an infested area, the direction of work activities can be used minimize the risk of spreading contamination. *Phytophthora* spread risk associated with soil-disturbing work activities or vehicular/pedestrian/livestock movement during wet conditions is minimized by conducting these activities from so that soil is moved from noninfested areas toward the infested area, but not in the reverse direction. In general, workflow can move from clean areas into infested areas without special precautions. However, contaminated items need to be cleaned and decontaminated when they leave an infested area to travel to noninfested areas.

By accounting for these steps in advance and planning workflow accordingly, it is possible to minimize the number of times that decontamination is needed. Swiecki and Bernhardt (2018) discusses this in greater detail.

5. Avoid risk-generating activities during wet conditions

In general, wet conditions tend to favor increased movement of soil and debris and provide better conditions for *Phytophthora* survival and infectivity. Hence, the risk of effective *Phytophthora* transport is much higher under wet than dry conditions. Risks associated with all activities increase under wet conditions, so risk-generating activities in infested or sensitive areas (foot and vehicle traffic, livestock grazing, construction activities, field work) should be avoided to the degree possible avoid when soil is wet enough to stick readily to feet, tools, equipment, and tires. The risk of spreading contamination via many activities, such as foot and vehicle traffic, can be virtually eliminated by avoiding infested or sensitive areas when soils are moist. Wet conditions require more frequent decontamination, and items contaminated with wet soil are more difficult to clean. Hence, decontamination activities require more time under wet or muddy conditions than under dry conditions. Consider the use of temporary or seasonal closure of access in areas where risk of spread to sensitive habitats is especially high.

The risk of moving infested soil by foot or vehicle traffic on dry roads and trails is lowest in mid to late summer and early fall. However, sites that are wet due to surface water or subsurface seeping will pose a risk even during the dry season. For activities that move subsurface soil, such as grading or excavation, risk is not limited to wet soil periods and precautions are needed year-round.

6. Review and modify grazing practices as appropriate to reduce risk of introduction and spread.

As discussed in section 4.4.1 above, the movement of livestock onto reserves and patterns of grazing employed have the potential to introduce and spread *Phytophthora* species via movement of contaminated soil. The risk of *Phytophthora* introduction and spread can be minimized by modifying grazing management. Cattle tend to congregate in less steep areas and stay close to water sources (George et al 2007). Such areas were also more likely than dry uplands to have *Phytophthora* species (Figure 3.1.1). Modeling of the spread of *Phytophthora austrocedri* into uninfested stands of *Austrocedrus chilensis* in Patagonia showed much greater potential for spread under cattle grazing than under a nongrazed scenario (La Manna et al 2013). Best management practices for slowing the spread of *P. cinnamomi* in Australia include managing potential spread of contamination by livestock (McCabe and Kilgour 2008).

Livestock grazing parameters can be managed to minimize the movement of soil between known infested areas and nearby receptive or sensitive vegetation. Altering the timing (avoiding wet conditions) and direction of movement (from clean toward infested) can be used to minimize risk that cattle or other livestock would move soil from infested areas to non-infested host vegetation. Livestock may be an important vector of *Phytophthora* between wet areas, including spring-fed ponds, season pools, and seasonal creeks. Use of developed water sources, such as water troughs, combined with fencing to exclude cattle from ponds, wetlands, and watercourses could be used to minimize risk of spread to and from these sites.

7. Manage runoff and flow from contaminated watercourses

On steeper slopes, eroding soil and rainwater flowing across the soil surface in drainages can move *Phytophthora* zoospores and other inoculum tens to perhaps hundreds of meters downslope in a single season. Inoculum can also spread long distances in watercourses. In sloping areas that have lost tree canopy due to disease or other factors, it is important to reestablish nonsusceptible native vegetation to slow runoff and minimize surface erosion.

Particularly in spring, seasonal watercourses that drain infested areas may carry zoospores and other infective propagules. Where possible, avoid channeling runoff from infested areas directly into watercourses that run through areas of susceptible vegetation. Allowing surface flows to be spread out over low receptivity areas (such as annual grasslands) or directing flows into layers where water will percolate into the soil before reaching areas with woody hosts should reduce the amount of inoculum that reaches susceptible vegetation.

Untreated water from infested watercourses or from portions of the reservoirs near where these watercourses discharge should not be used for irrigation or applications such as dust control.

Slow filtration through sand columns (about 1 m thick) has been shown to be effective for removing *Phytophthora* inoculum from irrigation water (Ufer et al 2008). This suggest the possibility that allowing infested water sources to percolate through constructed beds of clean sand could be a way to reduce *Phytophthora* before it is transported downstream toward sensitive habitat areas.

8. Minimize and eliminate direct routes that allow movement of contamination into sensitive habitat

Trails, roads, and direct runoff can serve as conduits that move *Phytophthora* contamination from infested source locations into sensitive habitats. Contamination is more likely to be spread across shorter and more direct routes than longer routes that cross through nonhost areas such as annual grasslands. To the degree possible, avoid creating new trails, firebreaks, drainages, or other connections that facilitate direct movement from infested areas or into sensitive areas, such as *Ceanothus ferrisiae* habitat. Where possible, decommission or reroute existing connections to avoid short, relatively direct connections between *Phytophthora* sources and noninfested host vegetation.

9. Road and trail surface modifications

Where roads or trails crossing through infested areas are subject to saturation or puddling, employ changes in drainage, tread or road surface material, and road or trail elevation to minimize the likelihood that vehicles, pedestrians, equestrians, bicycles, or other users would pick up and move soil during wet conditions.

10. Use signage and cleaning stations

Where appropriate, signage can be used to identify known *Phytophthora*-infested areas and inform staff or other users of precautions that should be taken. At appropriate locations, boot brushes or other decontamination supplies can be made available to facilitate removal of contamination before entering clean areas or upon leaving infested areas.

11. Do not install new plantings of susceptible hosts into areas known or likely to be infested with *Phytophthora.*

Planting susceptible hosts into *Phytophthora*-infested soil not only creates an unsustainable situation for the new plants, but can also allow *Phytophthora* populations to increase and facilitate additional secondary spread. Such sites include known infested areas as well as the immediate vicinity of conventional nursery stock planting sites, whether the previously planted stock has died or is still alive. *Phytophthora* inoculum can persist for extended periods in soil after the infected host has died.

Phytophthora-infected plants may survive for many years and may appear healthy, though often with reduced vigor.

12. Consider measures to prevent rooting by pigs in *Phytophthora* infested areas.
Because they disturb surface soil and excavate roots, feral pigs are likely to increase opportunities for secondary spread of *Phytophthora* from infested areas. Tilling of the soil beneath infected plants, particularly oaks, has the potential to expose soil containing *Phytophthora* and unearth infected roots. This infested material is then more likely to be moved by pigs, livestock, or flowing water. Removal of pigs and use of exclusionary fencing are possible management options.

4.3.2. Eradication

Eradication of existing infestations is typically only an option for very limited areas, such as plantings of *Phytophthora*-infected nursery stock. Although eradication is relatively expensive on a unit area basis, it can be more cost efficient to eradicate localized spot *Phytophthora* infestations (e.g., individual planting sites) rather than allow the pathogen to spread into surrounding vegetation and eventually downslope throughout the watershed. Eradication is most likely to be an option where infestations can be detected early and affect limited discrete, identifiable areas. At present, application of this approach would be limited to relatively recent or small plantings of infected nursery stock within reserves, especially at critical locations where inoculum could spread to large areas. The *Phytophthora cambivora*-infected planting in the upper watershed at Joseph Grant Park (JG09) is an example of a site where this approach would be warranted.

Use of heat to eradicate *Phytophthora* from soil

Compared with many other microorganisms, *Phytophthora* and other water molds are relatively sensitive to high temperatures. Research has also consistently shown that *Phytophthora* propagules are killed at lower temperatures and shorter times if the soil is moist. The minimum time/temperature combination needed to ensure mortality of *Phytophthora* with moist heat has historically been considered to be at least 30 minutes at 50 C (122 F) (Baker 1957). Because heat tolerance varies between species, a safety margin beyond this minimum is desirable, achieved by increasing the exposure time and/or the temperature (e.g., at least 55 C [131 F] for 1 hour). Recent data showed 1.2 hours at 50 C was necessary to kill *P. pini*, although *P. ramorum* was killed in 20 minutes (Funahashi and Parke 2016).

Phytophthora mortality shows a logarithmic relationship with temperature and time of exposure. As the maximum temperature reached decreases, exposure times need to be lengthened logarithmically to kill *Phytophthora* propagules. Data collected from long-duration solarization tests (at least 9 months) indicate that treatments can be effective even if maximum soil temperatures are less than 50 C, but temperatures need to exceed 35 C for at least 100 hours to eliminate *P. cactorum*.

Some options for heat-treating spot *Phytophthora* infestations are compared in Table 4-2 below. Of these, only small area, long-duration solarization has been tested extensively to date. Field tests for other methods are still in planning stages, although the basic concepts have been proven in tests. In general, methods that agitate soil during heating attain target temperatures faster and more efficiently than methods that apply heat to a static soil mass.

Table 4-1. Comparison of methods for heat-treating small volumes of soil to eradicate *Phytophthora*.

Method	Characteristics: Static/ agitated In situ / excavated Heat input sources Energy sources	Current status	Potential uses
Steam auger	Agitated in situ steam fuel	Basic performance parameters are known from orchard tests. Has not yet been tested and calibrated for variable field conditions associated with habitat restoration sites.	Sites accessible by large equipment (skid steer, steam generator). Most efficient for treating many sites in localized areas.
Auger with heat input via collar	Agitated in situ heated air, steam fuel, electricity	Proof of concept tests using high temperature air as the heat source show that method is viable. SCVWD is developing a full-scale prototype that has not yet been tested.	As above, also sites only accessible with smaller equipment. Most efficient for treating many sites in localized areas, but viable for more scattered sites
Small area, long-duration solarization	Static in situ radiant solar	Results from one large test shows good efficacy for full sun sites with at least 1 m × 1 m square greenhouse film. Soil temperatures >35 C for about 100 h or more appear to be needed. These temperatures are attainable in the upper 10 cm of soil, but may not be achieved below 20 cm.	Full-sun sites that are not readily accessed with heavy equipment and where plastic film will not be disturbed. More appropriate for sites planted with small container stock (rootball depth <20 cm).
Solar oven	Static excavated radiant solar	Small scale testing with simple ovens show that soil can be heated to target temperatures in one day during summer with full sun exposure. Could be optimized for field use but requires excavation of planting site and at least nearby solar exposure.	Sites in full sun or in close proximity to full sun sites. Potentially useful for treating small numbers of widely scattered sites, such as dead plants identified during monitoring.
Heated chamber	agitated or static excavated radiant, heated air, steam fuel	Not yet tested for soil heating, but technology is well-established. Requires excavation. Modified asphalt kettle might be adaptable for this use, though modification would need to be made to facilitate dumping of the heated soil and to utilize agitation.	Labor and associated equipment inputs may be on par with other more efficient in-situ methods
Steam injection (via wand or tines)	static in situ steam fuel	Has been studied in field situations. Steam diffusion is greatly limited by low soil porosity, so method requires many injection points and relatively long duration. Slower and less efficient than alternatives using steam with agitation.	May be adaptable for treating small numbers of sites if a small steam generator can be used. Not efficient for treating large numbers of sites. Augering of site may be needed to permit insertion of steam injectors.

Effects of Fire

Because *Phytophthora* species are sensitive to heat, the question naturally arises as to whether fire can be used to manage *Phytophthora* root rot. Over many decades of research, fire has not been identified as a viable means for controlling root-rotting *Phytophthora* species. Studies in Australia have in fact found that fire decreased plant diversity and increased mortality of susceptible species in areas invaded by the root-rotting pathogen *P. cinnamomi* (Moore et al 2014, Moore et al 2017). The authors suggested worsened disease outcomes could be due to an increase in stress and therefore susceptibility among plants which survived fire. They also suggested that the reduced vegetation layer allowed the soil to become warmer (due to reduced shading) and wetter (less soil water use by burned vegetation) and therefore more conducive for *P. cinnamomi*, which is favored by moist and warm soil.

Phytophthora species that infect roots may be found to depths as great as 1 m, but are mostly found in association with plant roots in the upper 30 to 60 cm of the soil profile. Although fires heat the soil surface to high temperatures, maximum soil temperatures from surface burns decrease substantially with increasing soil depth due to the poor thermal conductivity and high heat capacity of soil. Temperatures lethal to *Phytophthora* and other microorganisms may only extend a few cm in to the soil, especially if it is moist (Valette et al 1994). In studies with the root pathogen *Armillaria oryzae*, recovery of *A. oryzae* from stem segments buried at 8 cm was reduced in burned plots but no difference in recovery was seen among stem segments buried at 30 cm (Filip and Yang-Erve 1997). Because of these innate limitations, surface fires are not a practical means for reducing *Phytophthora* levels in the soil.

4.3.3. Suppression

Suppression is, in most cases, the approach of last resort and is used to minimize further unassisted spread of *Phytophthora* pathogens through stands that have a high conservation value, such as Coyote ceanothus. Most suppression techniques require repeated treatments and because the pathogen is not eliminated from the treated area, actions to prevent secondary spread from the infested areas are still required. Some approaches that may be applied to suppress root-rotting *Phytophthora* species are described in Table 4-2.

Table 4-2. Methods for suppressing soil-borne *Phytophthora* diseases that may be applicable for use in some native habitat areas.

Drying	*Phytophthora* reproduction and spread is greatly curtailed under dry conditions.	May be implemented by: -Ceasing irrigation in planted sites. -Allowing sites to remain dry for extended period by covering with impermeable material (such as in solarization). -Reducing moisture by redirecting runoff or providing drainage. Soils may not dry sufficiently to provide significant control.
Host free period or zone	A host-free period may need to extend for many years to completely eliminate *Phytophthora,* but the absence of hosts will prevent additional inoculum production.	Do not plant or replant into infested planting basins or other infested areas. Control weedy vegetation that may be hosts. Maintain a host-free buffer between infested areas and noninfested hosts by removing host plants and/or trenching and installing a barrier to eliminate root expansion into the buffer.
Potassium phosphite application	Potassium phosphite is a low toxicity inorganic salt with systemic activity against *Phytophthora* when applied to plants. It suppresses disease but will not eradicate the pathogen from the soil or infected plants.	Application of potassium phosphite to uninfected *Phytophthora* host plants at edge of infested area may help reduce further spread and resulting plant mortality, Phosphite is applied to the foliage, but plants must be live and not under drought stress for sufficient uptake to occur. Phosphite can cause burning of foliage, so phytotoxicity tests are needed to determine safe rates that can be applied to individual plant species.
Biological control (natural or augmentative).	In some areas, increasing soil organic matter can increase the activity of microorganisms antagonistic to *Phytophthora*. Antagonism is related to the microbial cellulase activity; *Phytophthora* cell walls are cellulosic.	Cultural practices that increase soil organic matter (especially with materials high in cellulose) can be used to favor native antagonists and reduce *Phytophthora* populations. This tactic is not applicable to poor soils such as serpentine that are normally low in soil organic matter. The use of exotic, commercially-produced antagonists is not appropriate for habitat areas due to unknown effects on other native soil microbes.

5. A RISK MODEL FRAMEWORK FOR IDENTIFYING PLANT COMMUNITIES AT RISK FOR *PHYTOPHTHORA* INTRODUCTION

This section describes a risk model framework that was used to identify plant communities that are most likely to be at risk of being invaded by *Phytophthora.* For this project, plant communities that had a high risk of *Phytophthora* invasion and were also identified as sensitive in the Natural Community Conservation Plan (NCCP) were assigned the highest priority for observation and sampling. This section contains an updated version of the document submitted as a project report on 30 November 2016.

5.1. Factors affecting *Phytophthora* root rot

The development of plant diseases caused by organisms such as *Phytophthora* is commonly described through a simple conceptual model known as the plant disease triangle. This simplified model indicates that disease development requires a favorable alignment of three factors: host plant, pathogen, and environment. Plant diseases develop when a susceptible host encounters a virulent pathogen under environmental conditions that are favorable for infection and disease development. Other factors also come into play. For soil-borne pathogens in particular, the presence of other agents that may either favor or suppress disease can strongly influence disease development. The overarching effect of time also needs to be considered because infection, disease, and dispersal processes all take time. For example, if environmental conditions, such as soil saturation, do not remain favorable long enough for infection and inoculum dispersal to occur, disease may be inhibited.

To establish relative risk ratings, we ranked these factors for their ability to affect diseases caused by root-rotting *Phytophthora* species (Table 5-1). Among **host factors**, the highest risk for *Phytophthora* root rot and spread exists where roots of susceptible hosts (either one or multiple host species) are relatively dense and interconnected. Environmental stresses may also predispose hosts to disease.

Considering **pathogen-related factors**, *Phytophthora* species are most likely to successfully establish in an area if they are well-adapted to local conditions, have a relatively wide host range, and readily produce sporangia and zoospores as well as survival structures. Such characteristics will vary between *Phytophthora* species for various host and environment combinations.

Environmental factors that favor pathogen introduction and disease spread can be divided into abiotic and biotic factors. Among abiotic factors, disease development is most strongly favored by periods of soil saturation, which may occur only during precipitation events or may be associated with irrigation, subsurface drainage, water courses, ponds, or seeps. Although temperature extremes can limit pathogen activity and disease development, the moderate soil temperatures found in the NCCP reserve system over much of the year are likely to favor a variety of *Phytophthora* species. Nonetheless, different *Phytophthora* species may be more or less active seasonally based on their temperature preferences.

The main biotic environmental factor that influences *Phytophthora* establishment, spread, and disease severity is the presence of effective microbial antagonists in the soil. If populations of such antagonists are low, risk of *Phytophthora* impacts are greater. Low populations of antagonists are often associated with poor soils with low organic matter, such as serpentine soils.

Table 5-1. Relative risk of *Phytophthora* introduction, disease development, and/or spread related to selected host, pathogen, and environmental factors.

Relative risk:	no risk	low risk	high risk
Host factors			
Density of susceptible host roots	not present	low density	high density
Continuity of susceptible host roots		wide spacing, low connectivity	highly interconnected
Host predisposition due to drought, salinity, low soil oxygen, or other stressors		little or no predisposing stress	high level of predisposing stress
Pathogen factors			
Host range	very narrow, no local hosts	narrow	wide
Adaptability	not adapted to local conditions	narrow, poorly adapted to local conditions	wide, well adapted to local conditions
Production of sporangia and zoospores (for rapid reproduction and spread)		low	high
Production of oospores, chlamydospores, and other survival structures (for persistence under unfavorable conditions)		not regularly produced or uncommon	readily produced, abundant
Abiotic Environmental factors			
Soil moisture	consistently dry	very well drained, seldom saturated	slow drainage (e.g., due to hardpan or claypan), periods of saturation
Temperature	above thermal kill levels	long periods at high temperatures (>30 C)	normal soil temperature range
Conditions at time of transfer		dry, hot	moist, moderate temperature
Biotic environmental factors			
Organic matter and related microbial activity		high	low

5.2. General model for *Phytophthora* introduction and spread

Introduction of *Phytophthora* to a site that is not infested occurs through a process with three interrelated steps:

1. Viable *Phytophthora* inoculum is present at a source.
2. The inoculum is transported from the source to the noninfested site.
3. The transported inoculum is brought in contact with susceptible vegetation at the site and an active infection is established.

These steps and corresponding risk factors associated with each are illustrated in Figure 5-1. Planting *Phytophthora*-infected nursery stock at a noninfested site accomplishes all three steps by placing viable inoculum and susceptible host material directly into the landscape. If the infested stock is planted in or near the rootzone of other susceptible vegetation at the site, all elements are in place to initiate an infestation. Other processes that move *Phytophthora* are less direct, and the likelihood of a successful *Phytophthora* introduction depends on the efficiency of each step in the process.

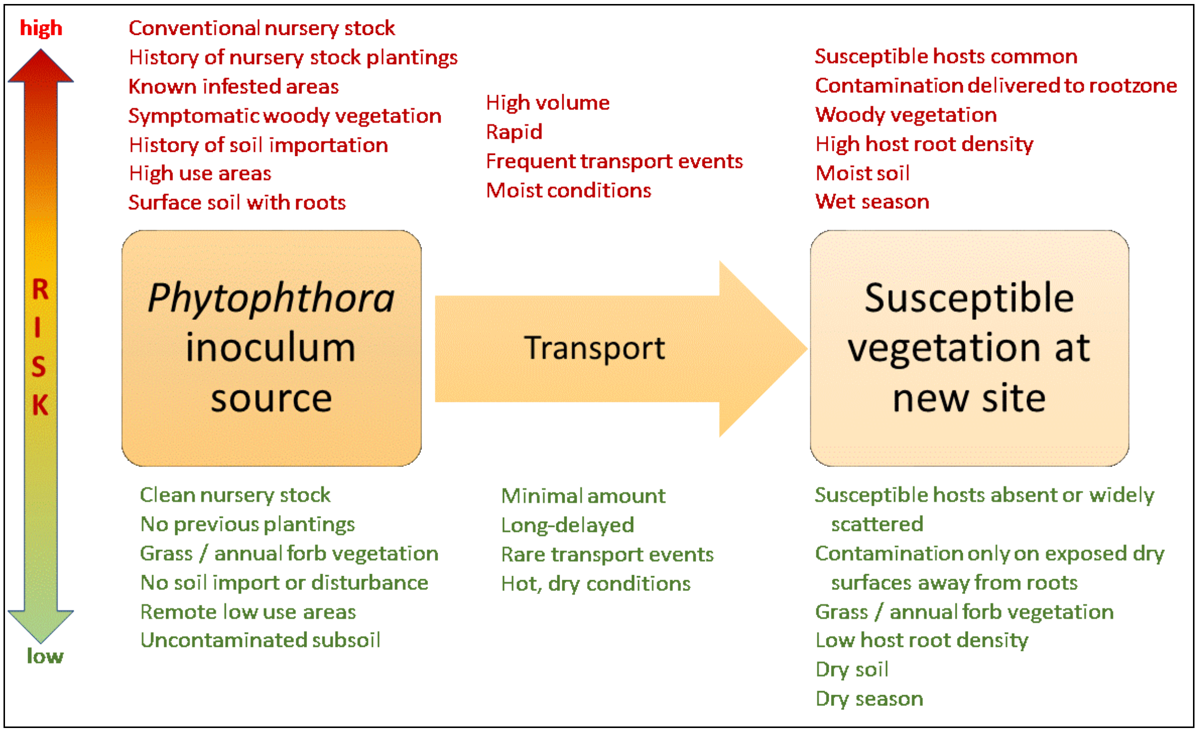


Figure 5-1. Diagram of the general risk model for introduction and spread of soil-borne *Phytophthora* species into uncontaminated sites.

5.3. Unassisted spread of *Phytophthora*

Once *Phytophthora* is introduced into a site and becomes established there, infested areas can function as sources for further spread. *Phytophthora* spreads naturally in infested landscapes via two main routes: **surface water flow**, which moves zoospores and other spores and infected plant fragments, and **root-to-root spread** between and along host roots in soil.

Natural (unassisted) spread via surface water flow primarily occurs downslope but can occur throughout an area that becomes inundated. Spores moving in water can move great distances downstream at the rate that water flows, though inoculum typically becomes more dilute as the distance from the source increases. Flowing water can transport inoculum across gaps where no hosts may be present. Infected plant debris transported in flowing water can increase the efficiency with which *Phytophthora* is moved. Plant debris, such as leaves, may be infected when they encounter inoculum in water, and may subsequently serve as a source of *Phytophthora* spores for an extended period while the debris is transported downstream.

In contrast, unassisted spread along roots requires a fairly continuous network of host roots and will not normally occur across gaps that are devoid of host roots. Root-to-root spread can occur in any direction, regardless of slope, as long as an intertwining network of host roots is present. Root-to-root spread is typically slow, commonly no more than about 1-2 m per year. Nonetheless, even with an expansion rate of 1 m per year along a disease front, infested areas can expand substantially each year. A small spot infestation with a 1 m radius (3.14 m^2, 6.3 m circumference) can increase over 120-fold in area (to 380 m^2, 69 m circumference) in 10 years by root-to-root spread.

5.4. Risk model parameters

The three steps shown in Figure 5-1 all contribute to the overall risk that a given activity may result in the introduction of *Phytophthora*. These factors interact in a multiplicative rather than additive fashion. This relationship can be illustrated in a simple mathematical model:

INTRODUCTION RISK = INOCULUM DENSITY × SOURCE VOLUME × SITE RECEPTIVITY

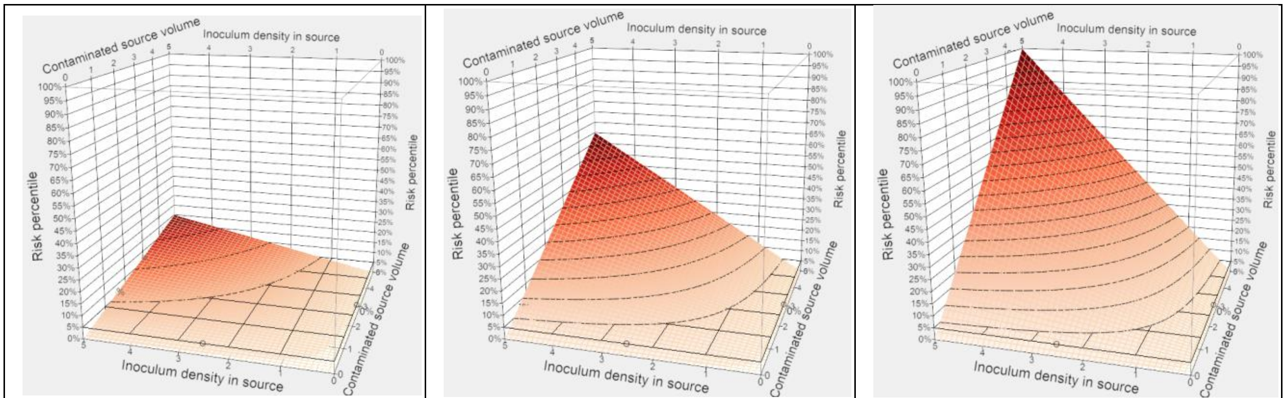
The factors in this model are:

1. **Inoculum density of the source**: overall source risk increases with the density of *Phytophthora* inoculum in the source material.
2. **Volume of contaminated source material transported:** the total number of *Phytophthora* propagules transported increases in larger volumes of contaminated material.
3. **Target site receptivity:** as site receptivity increases, smaller amounts of inoculum are needed to initiate an infestation.

This simple model can be used to help rate the relative risk of various activities that have the potential to move *Phytophthora* inoculum. If any of the factors is truly zero (no source inoculum, no infested material transported, or site completely unreceptive), the risk of *Phytophthora* introduction is also zero. Figure 5-2 compares INTRODUCTION RISK for three different levels of SITE RECEPTIVITY. It shows that for a given combination of INOCULUM DENSITY and SOURCE VOLUME, INTRODUCTION RISK increases as SITE RECEPTIVITY increases.

A low level of risk (represented as the flat gridded area to the outside of the 5% risk contour) is more likely to be achieved if site receptivity is low. With low receptivity, a wide variety of combined INOCULUM DENSITY and SOURCE VOLUME levels will be below the 5% cutoff of the risk slope (Figure 5-2A). In contrast, in highly receptive sites, the floor area below the 5% cutoff of the risk slope is quite limited (Figure 5-2C). For instance, if source material has high INOCULUM DENSITY, the SOURCE VOLUME will need to be very low to keep overall risk low. Because of these interactions, highly receptive sites have the greatest risk of becoming infested.

For management purposes, it is sufficient to reduce any one of these factors to zero to minimize the overall risk of introduction. For example, transporting even large volumes of soil to a susceptible site will not result in an introduction if there is no inoculum in the transported soil. When all three factors are nonzero, risk is lowest when risks associated with one or more of the factors are minimized.



A. SITE RECEPTIVITY: low - slightly receptive (e.g. dry, upland, widely separated woody hosts)	B. SITE RECEPTIVITY: moderate - moderately receptive (e.g. moist soil, seeps, moderate number trees/shrubs)	C. SITE RECEPTIVITY: high - highly receptive (e.g. riparian area, wet soil conditions, dense woody vegetation)

Figure 5-2. Risk of introducing *Phytophthora* from a source location to sites with low (left), moderate (center), and high (right) levels of site receptivity. Overall risk increases as inoculum density, contamination volume, and site receptivity increase. In the figures, a risk percentile of 5% or less, i.e., 5% of the maximum risk possible, is set as a low level of introduction risk. It is represented as the horizontal gridded plane that intersects the lowest visible contour line on the sloped surface.

5.5. Ranking risk of *Phytophthora* infection

Although some of the factors that contribute to risk can be assessed in the field, many are not readily observable or may vary across small spatial scales. For example, root density generally increases with increasing plant cover and density. However, root density and connectivity are often highly variable and can be difficult to assess in many plant communities. Soil conditions that may favor periodic saturation may also vary across fine scales that are not readily mapped. Pathogen factors, including host range and adaptability are incompletely known for most *Phytophthora* species. The species that might adapt well when introduced to a new habitat cannot be predicted. Nonetheless, the risk model suggests factors to consider when evaluating sites either on a landscape scale or at a given field location.

We used the factors discussed in Table 5-1 and other information to develop broader scale estimates of Phytophthora root rot risk based on readily observable features. In Table 5-2, land cover types, site characteristics, and activities associated with sites are considered in terms of their potential either as sources of *Phytophthora* contamination or situations in which *Phytophthora* introductions are likely to be successful.

Table 5-2 provides criteria that were used to identify at-risk plant communities in a GIS analysis. Starting with the land cover polygons used in the NCCP, we created variables that describe the relative risk that given land cover types might serve as sources of *Phytophthora* (developed land uses) or be at risk for invasion by *Phytophthora* (natural plant associations). The rankings are shown in Table 5-3. Most developed land uses are considered potential sources of *Phytophthora*. This assignment is primarily based on the widespread use of nursery-grown landscape plants in urban and suburban land uses. A high percentage of conventionally-produced ornamental nursery stock is typically infected with *Phytophthora* species, making nursery stock one the most common *Phytophthora* reservoirs and an efficient vehicle for spread of these pathogens due to its high inoculum density. Agricultural lands are also considered potential sources of *Phytophthora*, though the risk varies with cropping history and other factors.

Native vegetation land cover types considered to be at highest risk for *Phytophthora* invasion (high sensitivity) are those dominated by woody plants present at relatively high densities. As an exception to this rule, we have rated the *Phytophthora* invasion risk associated with conifer-dominated forests as unknown. Many conifers are *Phytophthora* hosts and *Phytophthora* is found in conifer forests, but we lack solid information on the impacts of soil borne *Phytophthora* in the specific conifer forest types in the county. This is of little practical consequence to this analysis because these forest types do not occur to a significant degree within the NCCP area.

The map shown in Figure 5-3 was developed by applying the rankings shown in Table 5-3 to the plan area. It shows that interface areas between potential *Phytophthora* sources and highly susceptible vegetation types occur widely but tend to be more concentrated on the west side of the valley. In particular, plant communities designated as sensitive that are also at high risk for *Phytophthora* invasion are more likely to be adjacent to potential *Phytophthora* sources on the west side of the valley (Figure 5-3).

Table 5-2. Relative risk of *Phytophthora* introduction, disease development, and/or spread related to selected land cover types, site characteristics, and activities.

	low risk	intermediate risk	high risk
Susceptible vegetation			
Natural communities	upland annual grasslands	open savannah with annual understory	hardwood forest
	upland low density annual forbs	sparse shrubland	dense chaparral or scrub
		sparse tree/shrub mixtures	dense chaparral/forest mix
			perennial or seasonal wetland and riparian
Current vegetation characteristics	dry uplands with only annual grasses and forbs	woody hosts as scattered individuals or patches in grasslands or sparse vegetation	contiguous woody vegetation with dense, interwoven roots
Vegetation symptoms	all species growing vigorously		one or more species showing decline typical of root diseases
Host susceptibility and predisposition	relatively resistant hosts, no significant predisposing stresses		highly susceptible hosts, due to genetics or predisposing stresses
Cover of susceptible vegetation	low, scattered	moderate, at least some patches disconnected	complete or nearly complete cover
Uniformity of susceptible vegetation	susceptible species scattered, high diversity including multiple resistant or nonhost species	patchy distribution of susceptible species with gaps lacking hosts	stands of single susceptible species or of a few similarly susceptible species
Site factors			
Edaphic factors	very well drained, high soil organic matter	subject to at least periodic saturation	low soil fertility, low soil organic matter, subject to regular periods of saturation or flooding
Access	remote areas without trail /road access	low to moderate road/trail use, not directly accessed from potentially contaminated sites	high use unsurfaced trail/roads near landscaped, agricultural, or other likely contaminated areas
Land use history	no history of developed uses, including planting, road building, grading, soil import	older history includes planting stock or other possible introduction with soil or plant material	recent or current uses known or likely to involve contaminated plant material, e.g., from landscape plantings

	low risk	intermediate risk	high risk
Potential contamination sources			
Habitat restoration sites (not following new *Phytophthora* BMPs)	no nursery stock, no grading, minimal disturbance other than seeding	no nursery stock but significant soil grading or import of soil or mulch	planted with nursery stock, import of soil or other soil-embedded materials (e.g., rootwads, fence posts) from possible contaminated sites
Urban development	hardscape (no landscaping) or turf only, no woody plants		urban landscaping with woody perennials
Agriculture	small grains, grass hay only		orchards
Movement of contamination from off site			
Conditions at time of transfer	dry, hot		moist, moderate temperature
Types of material translocated	soil, no roots or infected debris	soil with roots or debris	conventional nursery stock
	uncontaminated subsoils	surface soils from low risk areas	surface soils from developed, agricultural, or disturbed wet areas
Methods of transfer	shoes or small tires along unsurfaced road/trail with variable or light soil moisture	surface soil on digging tools, in carts/wheelbarrows	surface soil import and grading with large equipment
	clean livestock moved in dry season		muddy livestock moved in wet season
Location where contamination is delivered	soil surface well away from host rootzone	soil surface in host rootzone	incorporated or washed into rootzone
Potential routes of incidental movement	no trail access or low-use trail sections far from potentially-contaminated areas	moderate to heavily used trail sections at moderate distance from potentially contaminated areas	high use trails, trailheads, parking areas adjacent or close to contaminated areas
Water movement	no water flow, drainage, or water transport from potentially-contaminated areas	infrequent flow or water transport (e.g., via wet equipment) from potentially-contaminated areas	seasonal or perennial water flow from infested or potentially-contaminated areas

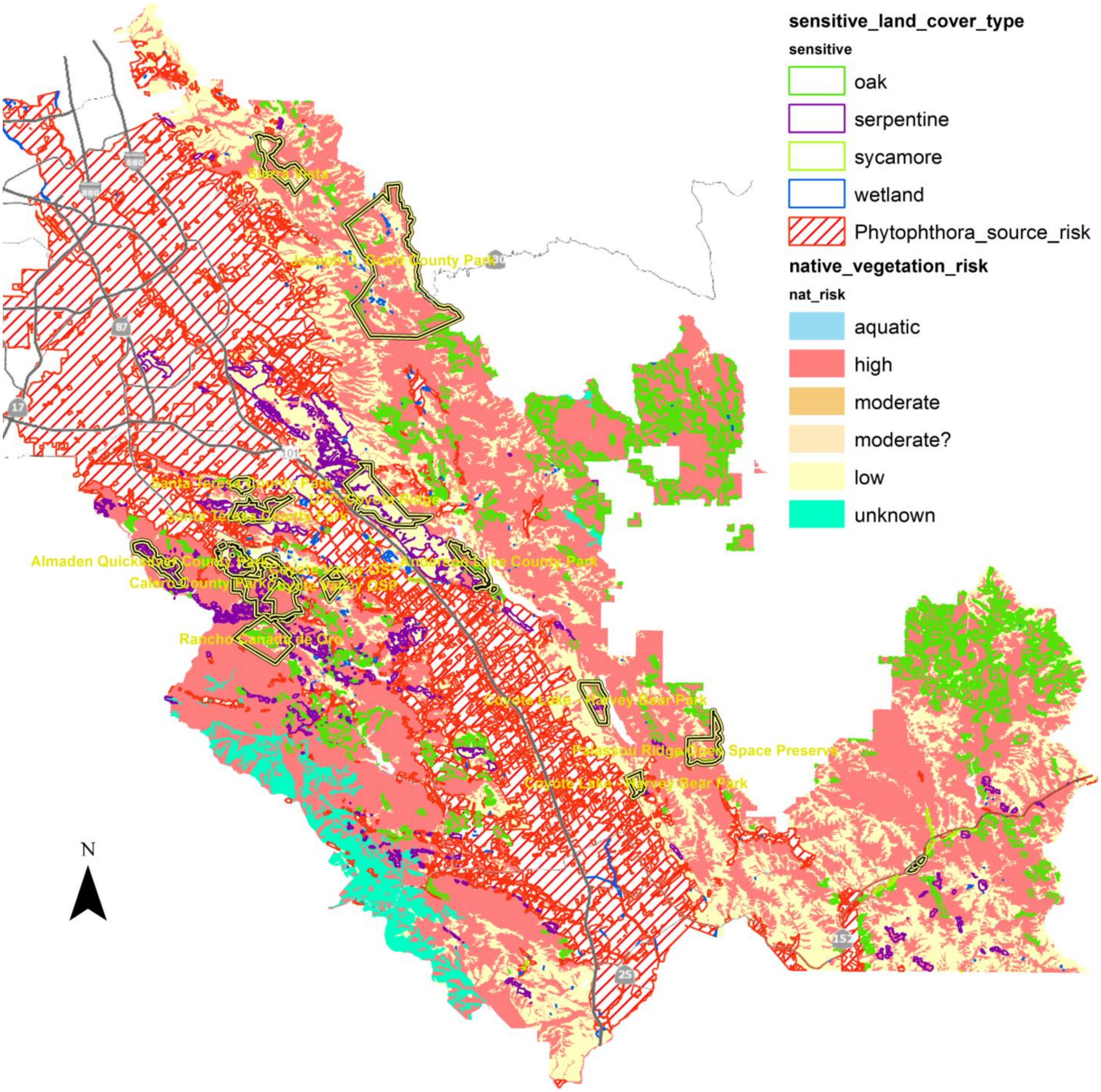


Figure 5-3. Map showing risk ratings from Table 5-3 applied to the plan area. Outlined areas indicate potential *Phytophthora* sources (red outline and hash) or denote vegetation types considered to be ecologically sensitive in the habitat plan (green, blue and purple outlines). Relative risk of *Phytophthora* invasion is denoted by colored shading. Yellow and black outlines are designated conservation reserves.

Table 5-3. Categorization of land cover classes within the habitat plan area as potential *Phytophthora* sources (rows with red border and shading) or relative risk for invasion by *Phytophthora.* Sensitive plant communities and *Phytophthora* sources are highlighted with the same colored borders used Figure 5-3.

Land cover class	Relative risk land cover is a source of *Phytophthora*	Relative risk of the natural community becoming affected by *Phytophthora*	Sensitive land cover types (grouped by category)
Agriculture Developed	high		
Barren		low	
Blue Oak Woodland		high	oak
California Annual Grassland		low	
Central California Sycamore Alluvial Woodland		high	sycamore
Coast Live Oak Forest and Woodland		high	
Coastal and Valley Freshwater Marsh		aquatic*	wetland
Coyote Brush Scrub		moderate	
Foothill Pine - Oak Woodland		high	oak
Golf Courses / Urban Parks	high		
Grain, Row-crop, Hay and Pasture, Disked / Short-term Fallowed	moderate		
Knobcone Pine Woodland		unknown	
Landfill	moderate		
Mixed Evergreen Forest		high	
Mixed Oak Woodland and Forest		high	
Mixed Riparian Forest and Woodland		high	
Mixed Serpentine Chaparral		high	serpentine
Northern Coastal Scrub / Diablan Sage Scrub		high	
Northern Mixed Chaparral / Chamise Chaparral		high	
Orchard	high		
Ornamental Woodland	high		
Pond		aquatic*	
Ponderosa Pine Woodland		unknown	
Redwood Forest		unknown	
Reservoir		low	
Rock Outcrop		low	
Rural Residential	high		
Seasonal Wetland		aquatic*	wetland
Serpentine Bunchgrass Grassland		low	serpentine
Serpentine Rock Outcrop / Barrens		low	serpentine
Serpentine Seep		moderate?	serpentine, wetland
Urban - Suburban	high		
Valley Oak Woodland		high	oak
Vineyard	moderate		
Willow Riparian Forest and Scrub		high	

* denotes land cover at risk of being infested with primarily aquatic *Phytophthora* species (mostly species in *Phytophthora* clade 6)

5.6. Location-specific risk assessment

The data in Figure 5-3 allow us to identify risks in only a broad way. For example, only a fraction of the area shown as potential sources of *Phytophthora* are likely to be infested. Even those that are infested may not be equally effective as sources of inoculum. Much more detailed analysis would be needed to rank source risks associated with individual landscapes. Furthermore, the primary routes of travel that might serve to move contamination from infested areas into susceptible habitats are not evident at this scale. Other *Phytophthora* sources, such as areas of infested native vegetation, do not show in this data representation.

In reviewing polygons against aerial imagery, it was clear that the available vegetation mapping was very coarse in many areas, leading to misclassifications that may be significant. For example, the Kirby population of Coyote ceanothus is located in polygons that are mapped as serpentine bunchgrass grassland and coast live oak woodland and forest. We noted other areas, including some within reserves, where susceptible vegetation types such as mixed serpentine chaparral (high risk) were not separately mapped but included within large polygons mapped to serpentine rock outcrop or serpentine bunchgrass grassland (both low risk). Because of these uncertainties, the land use layer does not provide enough information to assess relative disease risks at a local scale.

To prioritize potential sampling areas at a local level, we started by limiting our initial analysis to parks, open space preserves, and other units within the NCCP reserve system (Figure 5-3). To evaluate potential risks in these areas, we overlaid open polygons for the factors shown in Figure 5-3 on aerial imagery of the reserves. Using open polygons allowed us to observe finer vegetation and land use details than shown in the land cover layer. We also overlaid GIS layers for trails, road, and watercourses, and used 3-D renderings of the landscapes to examine relative elevations and drainage directions. Figures 5-4 and 5-5 show examples of these layers on base imagery of reserves and their surroundings.

Table 5-4 summarizes findings from this analysis. Within each of the reserve units, we noted those areas that should be considered as higher priorities for observation and sampling. These areas of interest are still based on general parameters, and actual sampling in the field was based on additional factors that could only be observed at the sites, especially plant symptoms. Furthermore, as noted in Table 5-2, past habitat restoration projects that involved the planting of nursery-grown stock constitute one of the most likely sources of *Phytophthora* introduction. We and researchers from the lab of Dr. David Rizzo, Dept. of Plant Pathology, UC Davis, sampled over 30 past restoration plantings within the plan area and found that a variety of nursery-grown plant material installed at these sites are infested with over 50 different *Phytophthora* taxa. None of the data layers that we reviewed included information about habitat restoration or other plantings in or near the reserves. Past restoration plantings or other nursery stock plantings in or near sensitive plant communities were considered a high priority for sampling when encountered during site visits.

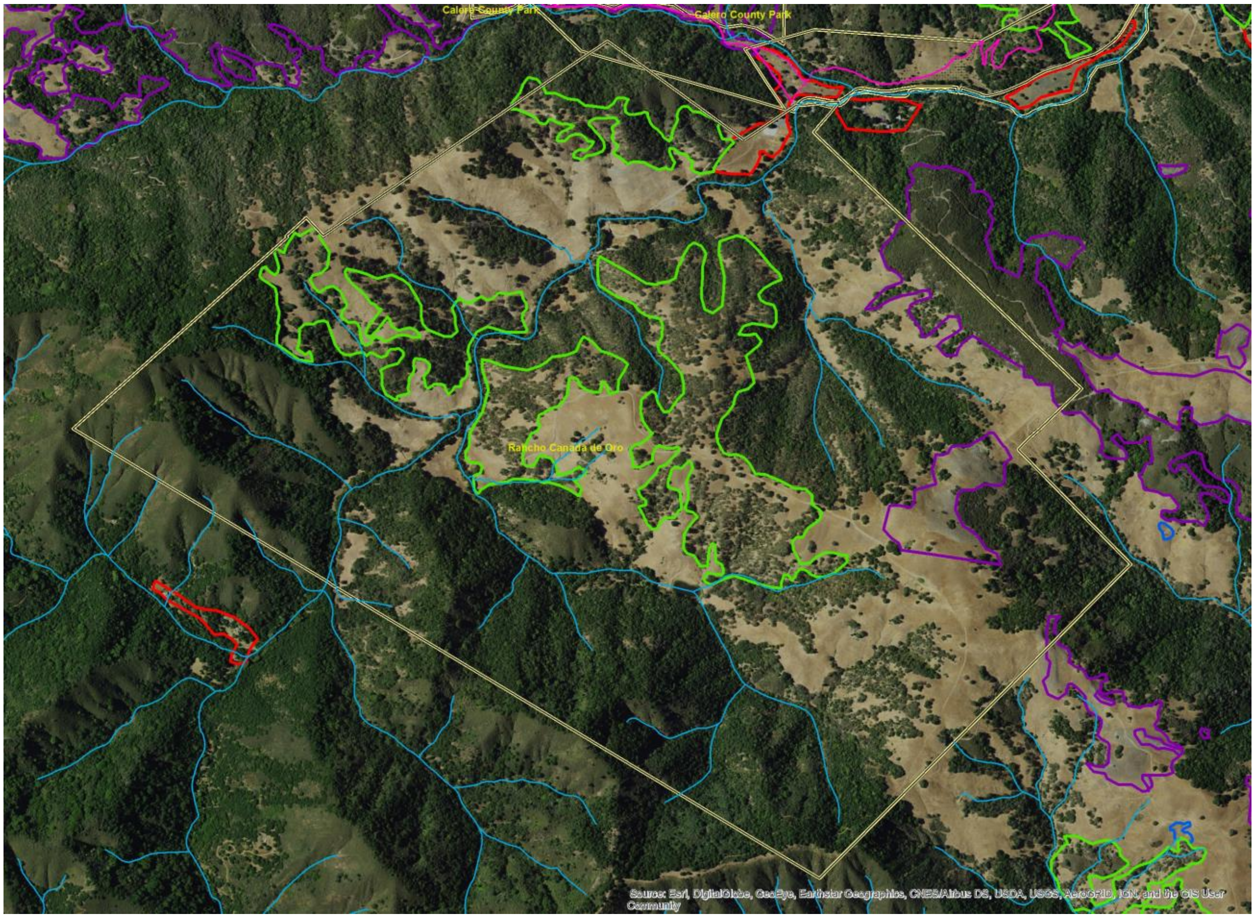


Figure 5-4. Map of Rancho Cañada de Oro Open Space showing overlays of watercourses (blue lines), sensitive vegetation types (green: blue oak woodland and foothill pine-oak woodland; purple: mixed serpentine chaparral and serpentine bunchgrass grassland) and developed areas (red outlines), and roads/trails (magenta lines). Note that various roads and trails evident in the photo are not included in the road/trail layer. Oak woodlands in the north area near the parking lot and entrance and the serpentine chaparral along the northeast border were considered areas of interest for sampling due proximity of roads and trails that connect back to developed areas.

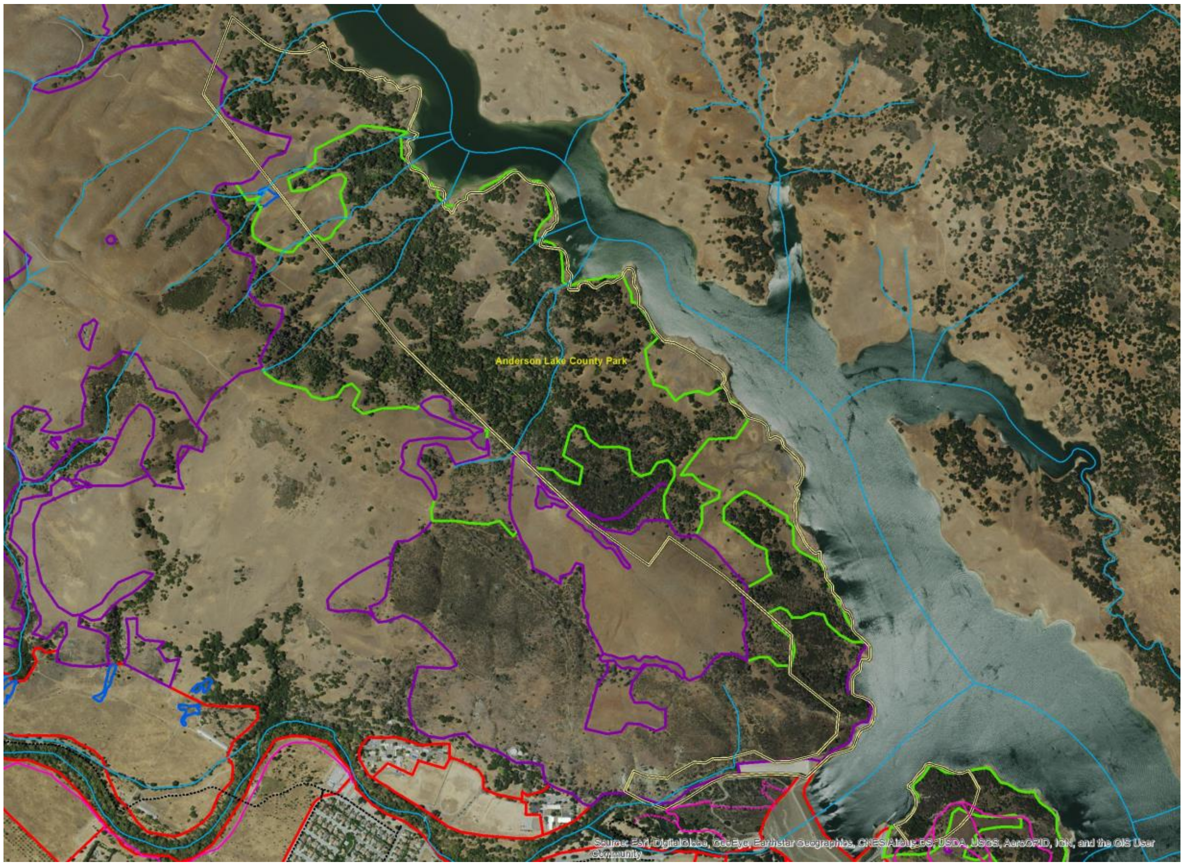


Figure 5-5. Map of Anderson Lake County Park showing overlays of watercourses (blue lines), sensitive vegetation types (green: foothill pine-oak woodland; purple: mixed serpentine chaparral and serpentine bunchgrass grassland) and developed areas (red outlines), and roads/trails (magenta lines). Note that various roads and trails evident in the photo are not included in the road/trail layer. A known *Phytophthora* infestation is located in the area south of the spillway and west of the dam at the bottom of the image. Highest priority areas for sampling at this location include areas north of the infested area and the point NE of the dam. This latter area includes Coyote ceanothus, though it is not shown by the land cover polygon for that area.

Table 5-4. Areas of interest for *Phytophthora* sampling in various units of the reserve system based on analysis of identified risk factors.

Reserve Unit	Area(s)	Vegetation types (sensitive = yellow highlight)	Risk factors for *Phytophthora* introduction	Notes
Almaden Quicksilver Co Park	SE lobe to E	Mixed serpentine chaparral	trails, earthwork areas	
	N edge and near NE border	Mixed serpentine chaparral	trails	
Anderson Lake	Hill N of spillway	Coyote ceanothus	trails, proximity to infested abutment area	
	point NE of dam	Coyote ceanothus	trails, proximity to developed area	
	Kirby canyon area	Coyote ceanothus	previous nursery planting	
	Dam abutment	Coyote ceanothus	trails, documented *Phytophthora* infestation associated with previous nursery plantings	
	NW road corridor	Foothill Pine - Oak Woodland	unpaved roads	
	PG&E hydro test areas	Coyote ceanothus	construction/grading, roads	
Calero County Park	Riparian areas S of Casa Loma Road	Mixed riparian forest/woodland	adjacent historical, remnant orchard trees, adjacent road - upslope	
	S entrance trails	Mixed riparian forest/woodland	trails passing through historical farmed land and remnant orchard	Area of interest noted by SCVHA
		Mixed serpentine chaparral		
		Mixed oak woodland/forest		
		Coast live oak woodland		
		Blue oak woodland		
	N entrance area near gate	California annual grassland	trails, roads	Area of interest noted by SCVHA
	SE entrance area near trails	Mixed oak woodland/forest	trails, roads, adjacent developed areas	Area of interest noted by SCVHA
		Serpentine bunchgrass grassland		
	Ponds	Pond	trails, roads, planned construction	Area of interest noted by SCVHA
Pacheco Creek Reserve	pond, creek, adjacent vegetated areas	Mixed riparian forest/woodland	roads, development upstream, tree mort at S end	
Coyote L-Harvey Bear Pk N unit	NE corner	Foothill Pine - Oak Woodland	road and development related to dam	
Coyote L-Harvey Bear Pk S unit	central east side	Coast Live Oak Forest and Woodland	trails, roads, adjacent development	not sure type is accurately mapped here
Coyote Valley OSP	N corner	Serpentine Rock Outcrop / Barrens	cattle use, current and former ag use adjacent	large portions are probably serpentine chaparral within OSP

Reserve Unit	Area(s)	Vegetation types (sensitive = yellow highlight)	Risk factors for *Phytophthora* introduction	Notes
Joseph D. Grant Co. Pk	NW corner	Blue oak woodland	unpaved road/trails	
	Trails access E side on 130	Blue oak woodland	trails, hwy proximity, developed area (not mapped) E side park	
	SW point	Blue oak woodland	trails, adjacent developed areas (not mapped)	
		Coastal and Valley Freshwater Marsh		
Palassou Ridge OSP	southeast corner	Mixed serpentine chaparral	nearby road corridor, adjacent development	some small developed areas not mapped
		Foothill Pine - Oak Woodland		
	south end, southeast corner	Central California Sycamore Alluvial Woodland	nearby road corridor, adjacent development	
Rancho Cañada de Oro	NE border	Mixed serpentine chaparral	roads in adjacent parcel in same veg type, but appears to be on other slope face, trail possibly connects across border near north end	
	near N parking area, along roads, central area	Blue oak woodland	developed area at parking lot, roads through center of OSP	veg types may not be very finely mapped at this location, appears to be more diversity than shown in layer
		Mixed oak woodland/forest		
Santa Teresa Co Park, N unit	SE area	Serpentine seep	trails, adjacent urban development	
		Mixed serpentine chaparral		
Santa Teresa Co Park, S unit	trails from N parking lot	Serpentine seep	trails, road, developed parking areas and structures (plantings?)	
		Mixed serpentine chaparral		
	S edge, E side	Northern Mixed Chaparral / Chamise Chaparral	roads, tower site	
Sierra Vista	Northeast section	Northern Coastal Scrub / Diablan Sage Scrub	extensive roads/trails, adjacent to developed area	
		Coast Live Oak Forest and Woodland		
UTC-Coyote Ridge	Central chaparral patch	Mixed serpentine chaparral	roads, cattle use?	sampling more related to baseline than high risk

5.7. Coyote ceanothus populations

Coyote ceanothus, one of the listed species in the plan, was a major focus of sampling. A stand in one of the three Coyote ceanothus populations (Anderson Lake) was known to be infested with multiple *Phytophthora* species (Figure 3.2.1-1), and *P. cactorum* had caused heavy losses in transplanted Coyote ceanothus nursery stock in a restoration planting. Areas in close proximity to any of the three Coyote ceanothus populations were considered to be priorities for sampling, particularly where water drainages, roads, or trails formed connections between potential *Phytophthora* sources and the Coyote ceanothus stands.

As shown in Table 5-4, a number of areas near the Anderson Lake Coyote ceanothus population were of interest for sampling due to various risk factors including the known *Phytophthora* infestation. The Llagas population is closely associated with possible sources of *Phytophthora* in adjacent residential landscaping, but stands are upslope from these potential sources of contamination and therefore not subject to contamination via water flow. The Llagas population and land surrounding it are privately owned and not readily accessible. Roads and trails do not directly connect the residential areas with the private lands where the Coyote ceanothus stands are located. Some trespass may occur from the residences into the stands, but the level of such activity would be much lower than with an open, high-use road or trail. Livestock use would have the potential to spread *Phytophthora* within these parcels and potentially from offsite. The Kirby population is relatively isolated from potential *Phytophthora* sources, although upon visiting the site we realized there was more use by people than we had initially anticipated. Livestock graze part of the population and might transport contamination to this area from elsewhere. Nursery-grown stock was reportedly planted in this area around 1993, but very few details about this planting were available, including the exact locations and number of planting sites and type and source of stock used.

5.8. Conclusions

The GIS-based analysis presented here provided a way to make a high-level cut across a large area to identify possible areas of interest for *Phytophthora* sampling in native habitats. The analysis was limited by the limited resolution and accuracy of available GIS layers and the lack of fine-grain data on plant condition and the location of potential *Phytophthora* sources, such as plantings of nursery stock. For these reasons, identifying general areas of interest for sampling (Table 5-4) was sufficient for selecting target areas. Selection of specific sampling areas is most appropriately conducted in the field where stand condition and other site factors can be observed. As the sampling proceeded, we used the areas identified in Table 5-4 as a starting point, but used field observations, accessibility, and results from testing to prioritize sampling areas as the project proceeded.

6. *PHYTOPHTHORA* SPECIES DESCRIPTIONS

Brief descriptions of *Phytophthora* species detected in this project are presented below.

Phytophthora acerina

Phytophthora acerina was described as a new species in the *P. citricola* group by Ginetti et al (2013). It was found causing a severe dieback of *Acer pseudoplatanus* (sycamore maple) plantations in northern Italy. Tests showed that *P. acerina* was highly pathogenic to *A. pseudoplatanus* and was pathogenic, although less aggressively so, to *Fraxinus sylvatica* (European beech) (Ginetti et al 2013). Genetic studies reported in the same paper showed that the 15 isolates the authors obtained from *A. pseudoplatanus* were genetically uniform and unique among European *Phytophthora* strains. They concluded *P. acerina* was a recent clonal introduction, and the most likely pathway for its introduction was nursery stock.

Besides the detection of *P. acerina* in water from Kirby Canyon, we are aware of several other detections in northern California. It was baited from the stump of a recently dead large coast live oak in front of Storer Hall on the UC Davis campus (Tyler Bourret, personal communication). In addition, it was baited from the Guadalupe River reach 1A restoration planting area in 2015 (Bourret 2018).

Phytophthora asparagi

A strain of *Phytophthora* that attacks asparagus (*Asparagus officinalis)* had been observed as early as 1996 in different parts of the world before the name *Phytophthora asparagi* was proposed (Saude et al 2008). A formal species description was not published until 2012 (Granke et al 2012). *P. asparagi* causes a soft, watery rot of asparagus spears, as well as crown and root rot (Saude et al 2008). *P. asparagi* has also been reported associated with decline and death of Mediterranean shrubland vegetation, including *A. albus* (a wild relative of cultivated asparagus), *Juniperus phoenicea*, and *Pistacia lentiscus* (Scanu et al 2015). Using seedlings grown in infested soil, Scanu et al (2015) completed Koch's postulates showing that *P. asparagi* was pathogenic to *J. phoenicea* and *P. lentiscus.* Root rot, wilting, and seedling death were observed, and the pathogen was reisolated from rotted roots. Interestingly, the isolates studied by Scanu et al (2015) have a higher temperature optimum and several morphological differences, although identical ITS sequence, when compared to the species description of *P. asparagi*. *P. asparagi* has also been reported to cause a basal leaf rot leading to plant death in *Agave, Yucca, Furcraea* (all Asparagaceae), and *Aloe* (Asphodelaceae) in a botanic garden in Australia (Cunnington et al 2005), and Agave in Italy (Cacciola et al 2006). *P. asparagi* was baited from a root/soil sample collected from the Guadalupe River reach 1A restoration planting area in 2015 (Bourret 2018).

Phytophthora cactorum

Phytophthora cactorum was described in 1886, but was first reported as a pathogen in 1870. It has a wide host range. The USDA fungal database (Farr and Rossman 2018) lists over 500 known host species and varieties, and this list does not include many recent new host records from California. Hosts include agricultural crops, such as strawberry, citrus, and *Prunus* species; hardwood trees and shrubs including oaks, maples (*Acer* spp.), Pacific madrone (*Arbutus menziesii*), and *Ceanothus*; conifers, including pines (*Pinus* spp.), true firs (*Abies* spp.) and Douglas-fir (*Pseudotsuga menziesii*); and many ornamentals. This pathogen is found in many parts of the world, primarily in temperate climates.

Phylogenetically it is a member of clade 1, which also includes *P. tentaculata*. It has caducous sporangia, meaning that sporangia readily detach and can be splash-dispersed or transported in runoff. This species is homothallic (does not need the opposite mating type to form oospores) and readily forms oospores. Oospores are a resistant spore type that contributes to longevity of this species in soil. Because oospores are sexual spores, they can also increase the genetic variability and adaptability of the pathogen population.

We have previously found *P. cactorum* associated with Pacific madrone decline on the San Francisco Peninsula. We and others have also found it to be common in nurseries and restoration plantings on toyon (*Heteromeles arbutifolia*) and other species, including ceanothus, mimulus, and coffeeberry. *P. cactorum* has also been found on *B. pilularis* in the past (French 1989). *P. cactorum* is closely related and very similar in appearance to *P. hedraiandra*, and some of the host records previously attributed to *P. cactorum* could be associated with this more recently described species. Also, genetic studies recently conducted by Tyler Bourret in the Rizzo lab (UC Davis), suggest that *P. cactorum* may be a cluster of related but distinct taxa. The implication of this is that any given *P. cactorum* isolate may differ from others with respect to range, pathogenicity, ecological adaptation and other characteristics.

Phytophthora cambivora (= *Phytophthora ×cambivora*)

Phytophthora cambivora is closely related to *P. cinnamomi* and is an aggressive root pathogen with a wide host range in clade 7a (Yang et al 2017). It was first described in 1917. This heterothallic (occasionally homothallic) species is believed to have originated as an interspecific cross between two unknown *Phytophthora* species sometime in the past (Jung et al 2017). Jung et al (2017) re-described the species as *P. ×cambivora* and designated a neotype, since the original type culture has been lost, and there were no designated ex-types or isotypes. There are numerous heterozygous positions in the ITS sequence of accepted *P. cambivora* isolates; variation of at least 3 base pairs from the neotype are acceptable for the species. Table 6-1 below summarizes comparisons between our *P. cambivora* isolates and two reference isolates.

Phytophthora cambivora has become naturalized in parts of Europe, where it causes ink disease of chestnut (*Castanea* species), and root and collar rot of beech (*Fagus sylvatica*) in forests (Belisario et al 2006). *Phytophthora cambivora* attacks nursery stock of various species in Europe and the US; it is commonly isolated from nursery stock in California. Between 2013 and April 2017, the pathogen was detected following sampling by CDFA staff in Alameda, Contra Costa, Marin, Monterey, Orange, Plumas, San Mateo, San Francisco, Santa Clara, Solano, and Sonoma Counties (Chitambar, 2017). In some Oregon forests, *P. cambivora* causes a lethal canker disease of giant chinquapin (*Chrysolepis chrysolepis*) (Vannini and Vettraino 2011). It also causes a collar rot of almonds and cherries (*Prunus* species), and apple (*Malus pumila*) in cultivation, and has been reported on Noble fir (*Abies procera*) in Christmas tree farms in Washington (Vannini and Vettraino 2011).

Reports indicate large amounts of variability in susceptibility of oak species to various isolates of *P. cambivora*. *P. cambivora* was reported to be a fine-root nibbler only in pathogenicity tests using *Quercus suber* (cork oak) as a host (Jung et al 2017). In contrast, Brasier and Kirk (2001) reported that *P. cambivora* isolates caused substantial cankers on *Quercus robur* (English oak). We have recovered *P. cambivora* from soil beneath declining, dead, or dying California native species including manzanita (*Arctostaphylos*) species, Pacific madrone (*Arbutus menziesii*), *Quercus lobata* (valley oak), *Q. agrifolia* (coast live oak), toyon (*Heteromeles arbutifolia*) in multiple locations on public and private lands, always in association with current or past disturbance (e.g., roads, trail, plantings, etc.).

Comparison of ITS sequences from isolates obtained during this study, as well as a few other local isolates, show a high degree of similarity to the neotype and each other, and less similarity to an isolate from Oregon (Table 6-1).

Table 6-1. Comparison of ITS sequences for *Phytophthora cambivora* isolates from this study, and two accepted *P. cambivora* isolates (Jung et al 2017).

	PR171221-JG09-6	**PR171229-CP28-3**	**PR171218-CL01-1**	**PR171218-CL03-1**	**P0592 noble fir *Abies procera* Oregon HQ643176.1 CBS114087**	**Neotype IT 5-3 KU899179.1 Jung et al 2017 Persoonia 38:100-135 from *Quercus pubescens* Italy in 2013**
PR171221-JG09-6		826/827	826/827	826/828		823/824
PR171229-CP28-3	826/827		831/831	832/833		823/823
PR171218-CL01-1	826/827	831/831		830/831		823/823
PR171218-CL03-1	826/828	832/833	830/831		815/819	823/824
PR170628-RO01-1	826/827	837/837	831/831	832/833		823/823
PR170317-AD30						812/812
PR170329-PV10-9 (San Mateo county)						821/821
PR170305-Toyon1 (Vacaville urban landscape)						810/810
P0592 noble fir *Abies procera* Oregon HQ643176.1 CBS114087						823/826

Phytophthora chlamydospora

Phytophthora chlamydospora (formerly taxon 'Pg chlamydo') is a clade 6 species closely related to *P. gonapodyides.* We have detected it in water sampling in San Mateo and Santa Clara counties, although less commonly than *P. gonapodyides* or *P. lacustris*. It is commonly detected in water in stream baiting conducted for *P. ramorum* in northern California (Bourret 2018). It has been found in waterways in many parts of the world, including South Africa, Chile, Vietnam, and China. This species has also been found in nurseries in California and Oregon (Parke et al 2014). Relatively little is known about the pathogenicity of *Phytophthora chlamydospora*. Cheryl Blomquist and colleagues at CDFA report that it causes leaf lesions in a number of woody nursery species, including strawberry tree (*Arbutus unedo)*, *Camellia* species, and *Rhododendron* species (Blomquist et al 2012). Sims et al (2015) indicated that it is a pathogen of alder in riparian settings in Oregon and Türkölmez et al (2016) showed that it caused root and crown rot in almond. We have detected it, along with *P. cambivora,* in soil collected under declining coast live oaks with root disease symptoms in Woodside, CA. At that site, nursery plants had been stored in the rootzone of the affected oaks for an extended period of time. It was also associated with dying coffeeberry and a young dead coast live oak at another San Mateo County site.

Phytophthora crassamura

The recently-described *P. crassamura* (Scanu et al 2015) is closely related to *P. megasperma*, which it strongly resembles morphologically. The ITS sequences of type materials of the two species differ by 5 base pairs. Scanu et al (2015) isolated *P. crassamura* from declining shrubland on two Italian islands. During the course of identifying this species, the authors found three isolates in GenBank (all from Australia) that had previously been identified as *P. megasperma*, but that matched *P. crassamura*. Scanu et al 2015 showed that *P. crassamura* infects roots of *Juniperus phoenicea* and *Pistacia lentiscus* seedlings. In addition, it was isolated from a collar lesion of *Picea abies* (Norway spruce) in a nursery (Scanu et al 2015). Sims et al (n.d.) also reported *P. crassamura* infected nursery plants, including *Cornus sericia*, *Diplacus aurantiacus*, and *Juncus effusus*. In sampling of Santa Clara County riparian restoration plantings in Santa Clara county, Heather Mehl and Tyler Bourret of the Rizzo Lab (UC Davis) recovered this species at six locations in association with *Diplacus aurantiacus, Sambucus nigra* ssp. *caerulea, Heteromeles arbutifolia, Artemisia douglasiana, Quercus agrifolia,* and *Salix.* This species has also been found in in association with poorly performing planted *Platanus racemosa* nursery stock in the Bay Area.

Phytophthora cryptogea complex

P. cryptogea was first described in 1919. It has a broad host range of at least 23 families, and many of its hosts are in the Asteraceae (Erwin and Ribeiro 1996). It is a member of clade 8a (Yang et al 2017). It is known as an important pathogen of ornamentals and woody plants. It has good saprophytic ability and can colonize dead organic matter (Bumbeiris 1978, 1979, cited by Erwin and Ribeiro 1996). Krober (1980) is cited by Erwin and Ribeiro (1996) as reporting that *P. cryptogea* can persist in soil for more than 4 years without a suitable host. It has been found in irrigation water, which may be related to its saprophytic and/or survival abilities. We have detected it in watercourses and in ephemeral ponds or runoff after a rainfall event in Santa Clara, Alameda, and San Mateo Counties.

P. drechsleri was first described in 1931. It is known from at least 40 plant families, primarily causing root rots, although it is also causes fruit rot on some hosts. *P. cryptogea* and *P. drechsleri* have been confused for a long time due to their morphological similarities. Morphological features that historically have been used to assign isolates to one species or the other were eventually shown to be unreliable, and over the years, some researchers have suggested the two species should be merged into one species. However, *P. drechsleri* can grow at temperatures above 35°C, a feature that distinguishes it from *P. cryptogea*, and recent phylogenetic studies support it as a separate species (Yang et al 2017).

Phytophthora taxon "*kelmania*" was first mentioned in plant disease literature in 2002, but has not yet been formally described. *P*. taxon *kelmania* has been reported on *Abies* spp., *Picea* spp., *Gerbera* sp., and *Coleus* sp.

All three of these species are closely related and isolates in this complex have been assigned to different species names over the years. A recent study by Safaiefarahani et al (2015) identified a new member in this species complex, *P. pseudocryptogea*, described below.

Members of the *Phytophthora cryptogea* complex are among the *Phytophthora* species commonly isolated from nursery stock in California, including *Diplacus aurantiacus* (Rooney-Latham et al 2015, Sims et al n.d.). We have recovered species identified as *P. cryptogea* from nursery plants including *Ceanothus, Torreya californica, Salvia mellifera*, and *Eriogonum fasciculatum.*

The CDFA Diagnostic lab changed to more sensitive sequencing techniques in 2016. We lack ITS sequence data from CDFA for isolates from 2015 Anderson Dam sampling for SCVWD, so are unable to assign more precise identifications to the *P. cryptogea* complex identifications from the dam abutment from that time.

Phytophthora gonapodyides

Phytophthora gonapodyides is a heterothallic species in clade 6 that does not form chlamydospores. It was isolated from apples in a pond in Denmark and first described in 1909 as *Pythiomorpha gonapodyides* (Petersen, 1909). It is closely related to *Phytophthora chlamydospora* and *P. megasperma.* It is commonly found in forest streams and wet soils in many areas of the world. It has good saprophytic abilities and has generally been regarded to be a weak pathogen; however, it is fair to say that its abilities as a pathogen are not well understood. It occasionally causes trunk cankers on hardwoods, including tanoak (Reeser et al 2008) and some European forest trees. It was recently reported to cause cankers on European beech (Cleary et al 2016). It has also been reported as involved in the decline of holm oak (*Quercus ilex*) in xeric conditions in Spain (Corcobado et al 2010).

Bienapfl and Balci (2014) report it as among the species infecting new shipments of nursery plants received in Maryland from California. They list it as isolated from roots of asymptomatic *Acer* rubrum as well as potting media and several other symptomatic and asymptomatic plants.

Strains of *P. gonapodyides* isolated for this study differed from the ex-type by zero to several base pairs.

Phytophthora inundata

Phytophthora inundata is a clade 6 species known to cause a root and collar rot of shrubs and trees in flooded conditions, including *Salix, Aesculus, Prunus,* and *Viburnum*. *P. inundata* was described as a new species in 2003 (Brasier et al 2003) although the species had been known as an undescribed taxon for some years prior to that. It has been found in Europe and South America and has become very common in waterways in Western Australia. It was also isolated in California from flood-irrigated alfalfa growing in the Imperial Valley (Ho et al 2006). Plant Pathologist Dr. Don Erwin (UC Riverside) made the isolations in 1997 from rotten alfalfa roots as a favor to an alfalfa plant breeder, but was unable to classify this species until *P. inundata* was named by Brasier et al (2003). Most isolates of *P. inundata* are heterothallic, requiring the opposite mating type to form oospores, although some strains are weakly homothallic (i.e., producing some oospore in single culture).

P. inundata was not on the list of *Phytophthora* species recovered from nursery plants by CDFA, as reported by Suzanne Latham at the SOD science symposium in June 2016. In a study of Oregon nurseries, it was found only one time, in soil below containers (Parke et al 2014).

All our detections of *P. inundata* from natural vegetation have come from water or root/soil samples collected near waterbodies in areas that are periodically inundated. We have previously detected *P. inundata* from water samples collected on the San Francisco Peninsula. Those isolates' COX2 sequences closely match *P. inundata*. The Rizzo lab collected *P. inundata* from soil/root samples of transplanted *Artemesia douglasiana* nursery stock along Guadalupe River reach 6 and a transplanted *Juncus* at Pajaro Basin Freshwater Wetland Project. The Rizzo lab successfully baited *P. inundata* × *humicola* hybrids and *P. humicola* using pickleweed stems from soil/pickleweed root samples collected around dead and dying plants at Coyote Creek Reach 1A salt marsh.

The *P. inundata* isolates we recovered from wet soil around ponds used by cattle (PR160817-CP13.7 and PR161026-LL06-1) had COX2 sequences that were closer to strains of *P. humicola* than to *P. inundata*, raising the possibility these could be hybrids. However, there are no COX2 sequences from ex-type cultures of either *P. inundata* or *P. humicola* in GenBank, which makes comparisons more uncertain. Pairwise comparisons of isolates suggest that our strains vary between locations (Table 6-2).

Table 6-2. *Phytophthora inundata* ITS sequence comparisons: ex-type culture and isolates from this study.

	PR160817-CP13.7	**PR161026-LL06-1**	**PR170628- STP09-5, PR170628- 12-1, PR170628- 12-2**	**Ex-type P246b GenBank AF266791.1**
PR160817- CP13.7		801/803	804/806	804/806
PR161026- LL06-1	801/803		802/803	803/804
PR170628- STP09-5 PR170628- STP12-1 PR170628- STP12-2	804/806	802/803	All isolates are 100% match to each other	811/811 809/809 808/808

Phytophthora lacustris complex

Phytophthora lacustris is a member of clade 6 commonly found in water or in wet soils. Nechwatal et al (2013) described *Phytophthora lacustris* as a new species and summarized what was known about this species. It was first isolated in 1972, from roots of *Salix matsudana*, and has since been found worldwide, including in the U.S. It was originally lumped with *P. gonapodyides* based on morphological characteristics, but was recognized as a unique species based on molecular studies in the early 2000s. Before formal publication as a new species it was referred to as *Phytophthora* taxon Salixsoil. The optimum temperature for growth of *P. lacustris* on corn meal agar is reported to be 28 to 30 C. Many of the *Phytophthora* species in clade 6 are often found in aquatic environments and are tolerant of high temperatures. Members of clade 6 are thought to be better saprophytes than those in the other clades. *P. lacustris* has been shown to be weakly or moderately aggressive on inoculation to *Alnus*, *Prunus*, and *Salix*. It is also reported in nursery stock in Europe and the U.S. *P. lacustris* isolates did not cause disease in pumpkin, corn, alfalfa, chile pepper, onion, oats, and barley seedlings when inoculated with hyphal suspensions (Stamler et al 2016). Numerous tests have found it incapable of sexual reproduction.

P. lacustris was found in a survey for *Phytophthora* species in streams in western and southwestern Oregon and Alaska (Reeser et al 2011). Only one isolate was obtained from Alaska, but 18% of isolates obtained from streams in western and southwestern Oregon were identified as *P. lacustris*. Eleven of 60 streams monitored were infested. Some isolates exactly matched the ITS sequence of the European reference isolate. Stamler et al (2016) reported *P. lacustris* from New Mexico at Dripping Springs and Soledad Canyon (Las Cruces) and in the Gila, Rio Grande, Rio Ruidoso, San Juan Rivers. We have recovered *P. lacustris* or taxa identified as *P. lacustris* × *riparia* hybrids from water samples from creeks in Santa Clara County (Adobe, Alameda, Alamitos, Coyote, Guadalupe, Silver, Thompson, Tick), especially in lower watershed areas, and in Alameda and San Mateo Counties.

ITS sequences of many of our isolates vary with respect to the degree to which they match the *P. lacustris* type. Hence, we have assigned our various isolates to *P. lacustris* complex, as further study is needed on the genetics of this group.

Phytophthora megasperma complex

First described in 1931 by Drechsler, *P. megasperma* is a member of clade 6 and an aggressive soilborne pathogen of agricultural and horticultural crops (Jung et al 2011) that is also commonly found in nursery stock. This species complex produces large oospores and is homothallic. The host range is wide, but is complicated by the fact that the taxonomy of this species is in flux. Many morphologically similar taxa formerly lumped into *P. megasperma* are phylogenetically unrelated. Based on genetic analyses, various *P. megasperma* varieties and subgroups, many of which have restricted host ranges, have been reclassified as species. including *P. sojae*, *P. medicaginis*, *P. trifolii*, *P. rosacearum*, and *P. sansomeana*. *P. sansomeana* is in clade 8, illustrating how much phylogenetic diversity is present among taxa originally considered to be *P. megasperma*. As noted above, some *P. megasperma* strains have recently been assigned to the new species *P. crassamura*. Several distinct groups are still included within *P. megasperma*, and further segregation of this species complex is likely. Isolates currently categorized as *P. megasperma* have been shown to affect a variety of woody hosts (both conifers and hardwoods), as well as many herbaceous hosts. We have previously recovered isolates classified as *P. megasperma* associated with declining Arbutus menziesii and Umbellularia californica. In addition, we have recovered *P. megasperma* complex isolates from outplanted nursery stock at multiple restoration sites. We have occasionally detected *P. megasperma* in water samples associated with recent rainfall and flooding events.

Phytophthora multivora

P. multivora was first described from Western Australia by Scott et al (2009). This member of clade 2 had been previously identified as *P. citricola* prior to the use of gene sequencing, when morphological characters were the primary method for identifying species. *P. multivora* causes root and collar rot of various endemic species in Western Australia. In addition, it has been isolated from field grown Monterey pines (*Pinus radiata*) from Christmas tree plantations in Riverside and San Diego counties (Sandlin et al 1992). Symptoms in infected Monterey pines included chlorosis, stunting, and death, and pathogenicity was confirmed via inoculation studies (Sandlin et al 1992). This isolate was initially identified as *P. citricola*, but subsequent genetic analysis of the isolate showed it to be *P. multivora* (P7902, Jung and Burgess 2009). *P. multivora* has also been detected in California nurseries. It was among the 8 species of *Phytophthora* found in arriving shipments of symptomatic and asymptomatic plants from west coast nurseries to Maryland (Bienapfl and Balci 2014). We have isolated it from dead nursery plants of *Ceanothus thrysiflorus* and CDFA has also isolated from nursery plants, including *Diplacus aurantiacus* and *Arctostaphylos* species (Rooney-Latham et al 2015).

Phytophthora pseudocryptogea

P. pseudocryptogea was described as a new species by Safaiefarahani et al (2015). The authors used isolates in their culture collection to study the genetics of *P. cryptogea*. Among the isolates they studied, they determined that six isolates formed a unique group within the *P. cryptogea* complex, and described these as *P. pseudocryptogea*. These isolates originated from Iran or Australia. Hosts listed include *Solanum melongena* (eggplant), *Xanthorrhoea preissii* (Western Australian Grass Tree), *Banksia cirsioides* (Proteacea), and *Isopogon buxifolius* (Proteacea). *P. pseudocryptogea* has been recovered from *Diplacus aurantiacus* and *Arctostaphylos uva-ursi* in native plant nurseries (Sims et al n.d.). Mehl and Bourret also detected *P. pseudocryptogea* in outplanted nursery stock of *Artemisia douglasiana*, *Heteromeles arbutifolia*, *Salix*, and *Juncus* in several riparian restoration sites in San Jose.

Phytophthora ramorum

P. ramorum was introduced into California via contaminated nursery stock in the latter decades of the 20th century and became a primary cause of hardwood mortality for some oak species and tanoak within infested areas by 2000. It causes lethal trunk cankers, referred to as sudden oak death, in *Quercus agrifolia*, *Q. kelloggii*, *Q. parvula* var. *shrevei*, *Q. chrysolepis*, and *Notholithocarpus densiflorus*. It also infects a wide variety of ornamentals and many native species, causing foliar blighting and/or shoot blighting that is not usually lethal. It is primarily an aerial pathogen, but is commonly baited from rivers and watercourses in areas where *Umbellularia californica* (California bay), or other foliar hosts such as tanoak, are prevalent. Spores produced on California bay leaves are washed into watercourses during rainy weather in the winter and spring. Its recovery in Llagas Creek in Calero County Park was not unexpected, given the high amount of bay foliage overhanging the river upstream from the sample location.

Phytophthora riparia

P. riparia is another clade 6 member that was described by Hansen et al (2012). It was recovered frequently in a survey of Alaskan streams and was also identified in water samples and a single riparian soil from western Oregon (Reeser et al 2011) and in California streams (Hansen et al 2012). More recently, Stamler et al (2016) also reported this species from the Colorado, Gila, Rio Grande, and San Juan Rivers in the southwestern US. Its closest relative is *P. lacustris*. Hansen et al (2012) and Stamler et al (2016) report finding isolates that are hybrids between *P. lacustris* and *P. riparia*. Little is known about the potential pathogenicity of *P. riparia*. *P. riparia* isolates did not cause disease in pumpkin, corn, alfalfa, chile pepper, onion, oats, and barley seedlings when inoculated with hyphal suspensions (Stamler et al 2016).

The two *P. riparia* isolates from this study appear very similar to each other and to the ex-type (Table 6-3). The ITS sequence of PR170628-CV03-1 is shorter than that of the other isolates, limiting the strength of the comparisons.

Table 6-3. *Phytophthora riparia* ITS sequence comparisons: ex-type culture and isolates from this study.

Isolate	PR170628-CV03-1	Ex-type CPHST BL 111
PR171221-JG05-1	616/616	820/822
PR170628-CV03-1		616/616 (one way)

Phytophthora taxon agrifolia

We first baited this undescribed *Phytophthora* species in 2016 from a root/soil sample of a poor-looking *Quercus agrifolia* nursery stock seedling from a restoration project in San Mateo County. The ITS sequence of this isolate was not especially close to any described species. The second and third known finds of this species were from sampling conducted in this study. We baited *P.* taxon agrifolia from a root/soil sample collected beneath mature *Quercus lobata* at Rancho Cañada de Oro Open Space Preserve and from a root/soil sample from small dead *Ceanothus ferrisiae* at the high-water line of Anderson Lake County Park. Although the Anderson Lake detection could be associated with nursery-origin landscape plants in the Holiday Lake Estates development (see section 3.2.1), the Rancho Cañada de Oro detection has no clear direct link to nursery stock. Given that the Santa Clara County finds are in widely-separated, unrelated sites, it appears that *P*. taxon agrifolia may have been present in the area for an extended period and other infested areas may exist.

Phytophthora taxon *europaea*-like

P. europaea was described from oak forests in Europe (Jung et al 2002) and North America (Balci et al 2007). Our isolate, PR170410-STP03-1, detected at Santa Teresa Park under declining *Umbellularia californica,* is close to *P. europaea*, but the ITS sequence differs by two base pairs from the *P. europaea* type (Table 3.3.8-2). Our isolate more closely matches a related *Phytophthora* that is proposed as a separate species (*P. cadmea*) by Tyler Bourret (UC Davis Department of Plant Pathology, David Rizzo lab). The ITS sequence of our isolate completely matches an isolate baited from a stream near Corvallis, OR (VI_1-2P; GenBank HM004226.1; Reeser et al 2011) and is one base pair different from an isolate from forest soil under *Q. alba* in West Virginia (BM 1/10; GenBank DQ313222; Balci et al 2007). Strains matching the West Virginia isolate have been isolated in northern California from *Umbellularia californica* leaves and stream water by the Rizzo lab (UC Davis) (Balci et al 2007). Little is known about the pathogenicity of *P. europaea* and related strains.

Phytophthora taxon forestsoil-like

This undescribed new species in clade 6 was originally baited from two rivers in Taiwan (Jung et al 2016). This taxon differs from its closest relative taxon forestsoil (from European forests) by 10-15 base pairs. Jung et al (2016) notes that it is the only *Phytophthora* species so far known to be common to river systems in both Taiwan and Portugal (unpublished data) and speculated the commonality may be due to long-standing trade relations between these areas dating back to the 16th century. No data are available about the pathogenicity of this taxon. We recovered this species in two different years from the ephemeral stream in the ravine bisecting the Coyote ceanothus population at Kirby canyon.

Phytophthora taxon ohioensis-like

Phytophthora taxon ohioensis has not been formally described as a new species. It was first isolated by baiting soil in an Ohio oak forests by Balci et al (2010). It was subsequently reported from Australia on *Corymbia calophylla* (common names - beautiful leaf eucalyptus, marri, redgum) in parks, gardens, and remnant natural bushland (Barbar et al 2013). Taxon ohioensis is a close relative of *P. quercina*, a species associated with oak mortality in European forests. Our isolate, PR171229-RO10, differs from the voucher specimen of taxon ohioensis by one base pair.

Phytophthora taxon raspberry

Although some strains of *P*. taxon raspberry (clade 6) were included within the new species *P. gregata*, other strains were not considered to be the same as *P. gregata* (Jung et al 2011). All isolates included in *P*. taxon raspberry by Jung et al (2011) were from Europe. Isolates were obtained from roots of *Rubus idaeus* in Sweden, *Ilex aquifolia* in Switzerland, *Betula pendula* in Germany, and baited from soil in a declining alder stand in Poland. We compared our isolates to two of these *P*. taxon raspberry isolates and the ITS sequences were identical.

Not much is currently known about *P*. taxon raspberry in California. Previous to this study, we detected it a few times in Santa Clara County and once in San Mateo County. All our finds were associated with soil/root samples from wet locations or water samples. *P*. taxon raspberry is a homothallic species, i.e., it does not need an opposite mating type to form oospores. We have observed oospores in cultures of our isolates. Limited data on this species suggests that it may be readily moved between locations with soil, especially soil from wet sites. Hence, it may be moved between ponds within and between locations in mud caked on livestock or equipment. Our detections of *P*. taxon raspberry in the north portion of Calero County Park and Joseph Grant Park were from ponds heavily used by cattle.

P. taxon raspberry was not on the list of *Phytophthora* species recovered from nursery plants by CDFA, as reported by Suzanne Latham at the SOD science symposium in June 2016. However, we detected *P*. taxon raspberry in a nursery bed of *Elymus triticoides* established from plants collected along Coyote Creek in San Jose. The presence of this species in a restoration nursery indicates that it can be introduced into nurseries with vegetative material and subsequently introduced into field sites via outplanting of infected nursery stock.

The original description of the closely-related *P. gregata* was based on specimens obtained from Western Australia (Jung et al 2011). *P. gregata* was detected in the rhizosphere of several different declining plants, including *Banksia prionotes*, *Hakea* sp., *Patersonia* sp., *Pinus radiata*, and *Xanthorrhoea preissii*. It was also detected in soil collected from a pasture. There are also records of *P. gregata* from Japan, China, and Tanzania. *P. gregata* was also detected in the rhizosphere and the root collar of dying *Pinus pinea* in Italy (Ginetti et al 2012). Sims et al (2015) reported *P. gregata* in a study of riparian alder ecosystems in western Oregon, noting it as the first report of this species from the U.S. They detected *P. gregata* in lower portions of watersheds surrounded by human disturbance. We are not aware of any finds of *P. gregata* in Santa Clara County or elsewhere in California at this time.

7. SUPPLEMENTAL TABLE

Table 7.1. Sample numbers, CDFA sequence numbers, and pest diagnostic report numbers for *Phytophthora* isolates.

Sample number	CDFA sequence number(s)	CDFA PDR number	*Phytophthora* Species	Location	Site type	Host species
PR160817-CP13.4b	4788, 4798	MV6P06578661	taxon raspberry	Calero CP - north	periodic flooding	herbaceous, grass, *Eleocharis*
PR160817-CP13.7	4787, 4797	MV6P06578660	*inundata*	Calero CP - north	periodic flooding	herbaceous, grass, *Eleocharis*
PR160817-CP15.6b	4789, 4799	MV6P06578662	taxon raspberry	Calero CP - north	periodic flooding	crabgrass, bermudagrass, monocots
PR160817-CP15.7b	4790, 4800	MV6P06578663	taxon raspberry	Calero CP - north	periodic flooding	crabgrass, bermudagrass, monocots
PR161024-K13-1	5213, 5220	MV6P06578710	*lacustris* complex	Kirby Canyon	water	water
PR161024-K13-2	5214, 5221	MV6P06578711	taxon forestsoil-like	Kirby Canyon	water	water
PR161026-LL06-1	5215, 5222	MV6P06578712	*inundata*	Tilton Ranch	periodic flooding	*Ceanothus ferrisiae, Frangula californica, Juncus xiphioides, Paspalum distichum, Cynodon dactylon, Carex* or *Cyperus*
PR170317-AD23-1	6037	MV6P06578742-1	*chlamydospora*	Anderson Lake CP	water	water
PR170317-AD23-2	6038	MV6P06578742-2	*gonapodyides*	Anderson Lake CP	water	water
PR170317-AD23-3	6039	MV6P06578742-3	*lacustris* complex	Anderson Lake CP	water	water
PR170317-AD30	6040	MV6P06578743-1	*cambivora*	Anderson Lake Dam Abutment	dry	*Frangula californica, Heteromeles arbutifolia*
PR170317-AD32-5	6125	MV6P06578743-2	*crassamura*	Anderson Lake Dam Abutment	dry	*Artemisia californica, Solanum umbelliferum*
PR170317-AD33-1	6126	MV6P06578743-3	*crassamura*	Anderson Lake Dam Abutment	dry	*Artemisia californica*
PR170317-AD33-2	6127	MV6P06578743-4	*crassamura*	Anderson Lake Dam Abutment	dry	*Artemisia californica*
PR170329-PR03-3	6128	MV6P06578744-1	*megasperma* complex	Palassou Ridge Open Space	water	water
PR170329-PR05-1	6045	MV6P06578744-2	*gonapodyides*	Palassou Ridge Open Space	periodic flooding	*Platanus racemosa, Quercus agrifolia, Toxicodendron diversilobum*
PR170329-PR05-2	6046	MV6P06578744-3	*gonapodyides*	Palassou Ridge Open Space	periodic flooding	*Platanus racemosa, Quercus agrifolia, Toxicodendron diversilobum*
PR170410-CP18			*ramorum*	Calero CP - south	water	water
PR170410-CP21-3	6149	MV6P06578746-3	*chlamydospora*	Calero CP - south	water	water
PR170410-STP03-1	6147	MV6P06578746-1	taxon *europaea*-like	Santa Teresa CP	periodic flooding	*Umbellularia californica, Quercus agrifolia, Quercus lobata*
PR170410-STP04-1	6148	MV6P06578746-2	*chlamydospora*	Santa Teresa CP	water	water
PR170517-PP04-1	6501	MV6P06578747-1	*gonapodyides*	Pacheco Creek Reserve	periodic flooding	*Platanus racemosa, Conium maculatum, Bromus diandrus, Cirsium vulgare*
PR170517-PP07-1	6502	MV6P06578747-2	*chlamydospora*	Pacheco Creek Reserve	periodic flooding	*Artemisia douglasiana*
PR170517-PP07-2	6503	MV6P06578747-3	*gonapodyides*	Pacheco Creek Reserve	periodic flooding	*Artemisia douglasiana*
PR170517-PP07-4	6504	MV6P06578747-4	*lacustris* complex	Pacheco Creek Reserve	periodic flooding	*Artemisia douglasiana*
PR170517-PP09-1	6505	MV6P06578747-5	*cactorum*	Pacheco Creek Reserve	dry	*Prunus ilicifolia*

Sample number	CDFA sequence number(s)	CDFA PDR number	*Phytophthora* Species	Location	Site type	Host species
PR170517-PR07-6	6506	MV6P06578748-1	*lacustris* complex	Palassou Ridge Open Space	water	water
PR170517-PR08-2	6507	MV6P06578748-2	*lacustris* complex	Palassou Ridge Open Space	water	water
PR170517-PR08-3	6508	MV6P06578748-3	*lacustris* complex	Palassou Ridge Open Space	water	water
PR170517-PR08-5	6509	MV6P06578748-4	*lacustris* complex	Palassou Ridge Open Space	water	water
PR170517-PR08-6	6510	MV6P06578748-5	*lacustris* complex	Palassou Ridge Open Space	water	water
PR170628-CV03-1	6785	MV6P06578756	*riparia*	Coyote Valley OSP	periodic flooding	watercress, grass, *Salix* sp.
PR170628-RO01-1	6786	MV6P06578756	*cambivora*	Rancho Cañada de Oro OSP	dry	*Quercus douglasii*
PR170628-STP08-5	6784	MV6P06578755	*multivora*	Santa Teresa CP	periodic flooding	*Umbellularia californica, Quercus agrifolia*
PR170628-STP09-5	6783	MV6P06578755	*inundata*	Santa Teresa CP	periodic flooding	*Baccharis pilularis, Elymus, Artemisia douglasiana*
PR170628-STP10-1	6782	MV6P06578755	*cryptogea* complex	Santa Teresa CP	periodic flooding	*Eleocharis, Quercus lobata, Artemisia douglasiana*
PR170628-STP12-1	6779	MV6P06578755	*inundata*	Santa Teresa CP	periodic flooding	*Quercus lobata, Rosa californica, Artemisia douglasiana, Sambucus nigra* ssp. *caerulea*
PR170628-STP12-2	6780	MV6P06578755	*inundata*	Santa Teresa CP	periodic flooding	*Quercus lobata, Rosa californica, Artemisia douglasiana, Sambucus nigra* ssp. *caerulea*
PR170628-STP12-3	6781	MV6P06578755	*pseudocryptogea*	Santa Teresa CP	periodic flooding	*Quercus lobata, Rosa californica, Artemisia douglasiana, Sambucus nigra* ssp. *caerulea*
PR171206-RO07-6A	8274	MV6P06578764	taxon agrifolia	Rancho Cañada de Oro OSP	periodic flooding	*Quercus lobata*
PR171206-RO07-9	8276	MV6P06578764	*crassamura*	Rancho Cañada de Oro OSP	periodic flooding	*Quercus lobata*
PR171218-AD37-4	8277	MV6P06578764	*asparagi*	Anderson Lake CP	periodic flooding	*Ceanothus ferrisiae*
PR171218-AD37-9	8278	MV6P06578764	taxon agrifolia	Anderson Lake CP	periodic flooding	*Ceanothus ferrisiae*
PR171218-CL01-1	8279	MV6P06578765	*cambivora*	Coyote Lake Harvey Bear CP	dry	*Quercus lobata, Quercus agrifolia, Heteromeles arbutifolia*
PR171218-CL03-1	8280	MV6P06578765	*cambivora*	Coyote Lake Harvey Bear CP	dry	*Quercus lobata, Toxicodendron diversilobum, Pinus sabiniana*
PR171218-CL05-5	8281	MV6P06578765	*pseudocryptogea*	Coyote Lake Harvey Bear CP	dry	*Acacia* sp., *Eucalyptus* sp.
PR171218-CL05-7	8282	MV6P06578765	*pseudocryptogea*	Coyote Lake Harvey Bear CP	dry	*Acacia* sp., *Eucalyptus* sp.
PR171221-JG05-1	8283	MV6P06578766	*riparia*	Joseph Grant CP	periodic flooding	*Salix* spp.
PR171221-JG07-2	8284	MV6P06578766	*gonapodyides*	Joseph Grant CP	periodic flooding	*Salix* sp., grass, *Mentha pulegium*
PR171221-JG07-5	8285	MV6P06578766	taxon raspberry	Joseph Grant CP	periodic flooding	*Salix* sp., grass, *Mentha pulegium*
PR171221-JG07-7	8306	MV6P06578767	*gonapodyides*	Joseph Grant CP	periodic flooding	*Salix* sp., grass, *Mentha pulegium*
PR171221-JG09-6	8286	MV6P06578766	*cambivora*	Joseph Grant CP	dry	*Quercus kelloggii*
PR171227-AD40-1	8307	MV6P06578767	*crassamura*	Anderson Lake CP	periodic flooding	*Ceanothus ferrisiae, Arctostaphylos glauca*
PR171227-AD40-5	8308	MV6P06578767	*chlamydospora*	Anderson Lake CP	periodic flooding	*Ceanothus ferrisiae, Arctostaphylos glauca*

Sample number	CDFA sequence number(s)	CDFA PDR number	***Phytophthora* Species**	Location	Site type	Host species
PR171227-AD40-9	8309	MV6P06578767	*chlamydospora*	Anderson Lake CP	periodic flooding	*Ceanothus ferrisiae, Arctostaphylos glauca*
PR171227-AD41-1	8310	MV6P06578767	*megasperma* complex	Anderson Lake CP	periodic flooding	*Ceanothus ferrisiae*
PR171227-AD41-3	8311	MV6P06578768	*gonapodyides*	Anderson Lake CP	periodic flooding	*Ceanothus ferrisiae*
PR171227-AD42-1	8312	MV6P06578768	*crassamura*	Anderson Lake CP	periodic flooding	*Baccharis pilularis*
PR171227-AD47-6	8313	MV6P06578768	*gonapodyides*	Anderson Lake CP	periodic flooding	*Ceanothus ferrisiae*
PR171227-AD47-7	8314	MV6P06578768	*crassamura*	Anderson Lake CP	periodic flooding	*Ceanothus ferrisiae*
PR171227-AD48-2	8315	MV6P06578768	*crassamura*	Anderson Lake CP	periodic flooding	*Ceanothus ferrisiae, Artemisia californica*
PR171227-AD48-5	8316	MV6P06578769	*crassamura*	Anderson Lake CP	periodic flooding	*Ceanothus ferrisiae, Artemisia californica*
PR171227-AD50-4	8317	MV6P06578769	*megasperma* complex	Anderson Lake Dam Abutment	dry	*Artemisia californica, Baccharis pilularis*
PR171227-AD51-2	8318	MV6P06578769	*cactorum*	Anderson Lake Dam Abutment	dry	*Ceanothus ferrisiae, Heteromeles arbutifolia*
PR171229-CP28-3	8319	MV6P06578769	*cambivora*	Calero CP - south	periodic flooding	*Quercus lobata*
PR171229-RO10	8401	MV6P06578771	ohioensis-like	Rancho Cañada de Oro OSP	dry	*Quercus lobata, Toxicodendron diversilobum, Frangula californica*
PR180110-CL06-1	8398	MV6P06578770	*crassamura*	Coyote Lake Harvey Bear CP	periodic flooding	mud and leaves stuck to bottom of boots
PR180110-CL14-4	8399	MV6P06578770	*gonapodyides*	Coyote Lake Harvey Bear CP	water	water
PR180110-CL16-1	8400	MV6P06578770	*crassamura*	Coyote Lake Harvey Bear CP	periodic flooding	water
PR180115-SV02-1	8402	MV6P06578771	*pseudocryptogea*	Sierra Vista OSP	dry	*Quercus lobata*, grass
PR180115-SV02-2	8403	MV6P06578771	*pseudocryptogea*	Sierra Vista OSP	dry	*Quercus lobata*, grass
PR180115-SV03-1	8404	MV6P06578771	*cactorum*	Sierra Vista OSP	periodic flooding	*Platanus racemosa, Artemisia douglasiana, Scrophularia californica*
PR180115-SV04-1	8405	MV6P06578771	*crassamura*	Sierra Vista OSP	periodic flooding	*Quercus lobata, Quercus agrifolia*
PR180117-AD53-1	8409	MV6P06578772	*crassamura*	Anderson Lake CP	dry	*Heteromeles arbutifolia, Artemisia californica, Baccharis pilularis*
PR180117-K16-2	8406	MV6P06578772	*acerina*	Kirby Canyon	water	water
PR180117-K16-4	8407	MV6P06578772	*lacustris* complex	Kirby Canyon	water	water
PR180117-K16-5	8408	MV6P06578772	*gonapodyides*	Kirby Canyon	water	water
PR180117-K17-1	8410	MV6P06578773	*lacustris* complex	Kirby Canyon	water	water
PR180117-K17-2	8411	MV6P06578773	taxon forestsoil-like	Kirby Canyon	water	water
PR180117-K21-7	8412	MV6P06578773	*gonapodyides*	Kirby Canyon	water	periodic flooding
PR180117-K21-8	8413	MV6P06578773	*gonapodyides*	Kirby Canyon	water	periodic flooding
PR180117-K22	8588	MV6P06578774	*gonapodyides*	Kirby Canyon	water	periodic flooding

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