Evaluating Threats Posed by Exotic *Phytophthora* Species to Sensitive Plant Communities in the Santa Clara Natural Community Conservation Plan Area[1]

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Extended Abstract

Root rots caused by exotic *Phytophthora* species have been associated with dying and declining vegetation in multiple native plant communities in the San Francisco Bay Area and elsewhere in northern California. This project focused on detecting *Phytophthora* species that are currently affecting or have the potential to seriously affect populations of covered plants in the Santa Clara Valley Habitat Conservation Plan/Natural Community Conservation Plan (HCP/NCCP) area (Swiecki and Bernhardt 2018). A key component of the Santa Clara Valley HCP/NCCP is the creation of an 18,800 ha reserve network within the plan area to protect and conserve covered species, natural communities, and ecosystem function in perpetuity. We developed a sampling strategy by using GIS data to determine where in the plan area 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. High-priority vegetation included rare and threatened species, as well as vegetation complexes that were poorly represented in the plan area. We also considered proximity to lands enrolled or proposed for enrollment in the HCP/NCCP reserve system, access, and in-field observations of vegetation symptoms and risk factors to determine sampling locations.

Green pear baits were used to detect *Phytophthora* in samples. *Phytophthora* species were cultured from lesions on baits onto cornmeal-carrot agar, and cultures of different morphotypes recovered were submitted to the California Department of Food and Agriculture (CDFA) Plant Pest Diagnostics Lab for identification by nucleotide sequencing of the ITS region of nuclear ribosomal RNA; COX2 was also sequenced for some cultures. Twenty-one water samples (2.5 L of water skimmed from the surface of streams, ponds, or lakes and baited immediately in the field with a green pear in a 3.8 L plastic bag) and 168 soil/root samples (3 to 6 subsamples collected under target plants, 1-1.5 L sample volume, roots collected preferentially by hand when digging samples) were collected. Soil samples that were already moist or saturated and near 20 °C at the time of sampling were baited on the same day they were collected. For dry and/or cold samples, soil moisture was adjusted to near field capacity and samples were maintained at 20-

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24.5 ºC (night/day) for 3-3.5 days to allow time for sporangia to form before being flooded and baited with green D'Anjou pears. Pear baits were maintained in water samples for 3 days, rinsed lightly, and observed for up to 5 more days for symptom development. Pears remained in soil/root samples until symptoms developed (normally not before day 3) or until 5 days from the start of baiting, rinsed, and observed for symptom development until day 8. Baited samples were incubated at temperatures that fluctuated between 20 ºC (night) and 24.5 ºC (day).

We collected 189 samples from 15 locations in 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 the three remaining populations of Coyote ceanothus (*Ceanothus ferrisiae*), an endangered species endemic to the county that is a conservation priority in the NCCP. In all, 20 *Phytophthora* taxa (table 1) were recovered from 53 samples (28% of total) from 14 of the 15 sampled locations. Eight *Phytophthora* species (most in *Phytophthora* clade 6) were detected in 13 of 21 water samples (67% of samples) collected in seven sampled locations. Water samples with *Phytophthora* were collected from ephemeral runoff along a road (*P. crassamura*), puddles on unpaved roads (*P. gonapodyides*), seasonal streams (*P. acerina*, *P.* taxon forestsoil-like, *P. gonapodyides, P. lacustris* complex), perennial streams (*P. chlamydospora, P. lacustris* complex, *P. megasperma* complex, *P. ramorum*), and a reservoir (*P. chlamydospora, P. gonapodyides, P. lacustris* complex).

Phytophthora species were recovered from 59% of 44 root/soil samples collected from sites in 13 locations that were periodically flooded, including riparian floodplains, seasonal creeks and ponds that were moist to dry when sampled, and margins of perennial spring-fed ponds. Samples from periodically flooded sites had the greatest diversity of *Phytophthora*; 16 taxa including 5 that were also found in water samples (table 1). *P. crassamura*, *P. gonapodyides*, and *P. inundata* were the most commonly detected species in these sites. Unusual taxa detected in these sample locations included *P. asparagi* and the undescribed taxa *P.* taxon agrifolia (previously known only from a nursery-grown *Quercus agrifolia* seedling planted in San Mateo County) and *P.* taxon europaea-like.

We collected the greatest number of root/soil samples (124) from uplands or flats and lowlands not subject to inundation. Sampled areas including upland *C. ferrisiae* habitat, oak woodlands, and chaparral or other shrublands. Six *Phytophthora* taxa were detected among the 14 positive samples (11%) from these dry sites, which were sampled at all 15 locations. *P. cambivora*, *P. crassamura*, and *P. cactorum* were the only species detected at more than one location (table 1). Another undescribed taxon, *P.* taxon ohioensis-like, was found in association with valley oaks (*Quercus lobata),* in one location. Five samples from transplanted nursery stock (upland or flat/lowland sites) at four reserves yielded two *Phytophthora* detections.

Table 1—Frequency of *Phytophthora* taxa detected in water samples (n=21) and root/soil samples from normally dry uplands and non-flooded lowlands (n=124) and seasonally wet sites (n=44).

Number of samples with detections	*Phytophthora* taxon	Sample site type: dry	seasonally wet	water
11	*Phytophthora crassamura*	3	7	1
10	*Phytophthora gonapodyides*	-	6	4
7	*Phytophthora lacustris*	-	1	6
6	*Phytophthora cambivora*	5	1	-
5	*Phytophthora chlamydospora*	-	2	3
4	*Phytophthora inundata*	-	4	-
3	*Phytophthora cactorum*	2	1	-
3	*Phytophthora pseudocryptogea*	1	2	-
1	*Phytophthora cryptogea* complex	-	1	-
3	*Phytophthora megasperma*	1	1	1
3	*Phytophthora* taxon raspberry	-	3	-
2	*Phytophthora riparia*	-	2	-
2	*Phytophthora* taxon agrifolia	1	1	-
2	*Phytophthora* taxon forestsoil-like	-	-	2
1	*Phytophthora acerina*	-	-	1
1	*Phytophthora asparagi*	-	1	-
1	*Phytophthora* taxon europaea-like	-	1	-
1	*Phytophthora multivora*	-	1	-
1	*Phytophthora* taxon ohioensis-like	1	-	-
1	*Phytophthora ramorum*	-	-	1
	Number of taxa	**7**	**16**	**8**

Phytophthora was not detected in dry upland *C. ferrisiae* habitat in two of the three populations. However, *P. acerina, P. lacustris,* and *P.* taxon forestsoil-like were detected along a seasonal stream below the Kirby Canyon population and *P. inundata* was found on the edge of a spring-fed pond adjoining the Llagas population. An extensive, but still localized, infestation involving multiple *Phytophthora* species near the Anderson Lake reservoir poses the greatest threat to the largest remaining population (fig. 1). At least 2.8 ha of a lower slope area that includes part of this population was apparently infested with multiple species via the planting of infected *C. ferrisiae* nursery stock as part of a 1993 habitat restoration planting. *P. cactorum, P. cambivora, P. crassamura*, *P.* 'kelmania', *P. megasperma* and *P. syringae* have been detected here in recent and prior sampling. No *Phytophthora* was detected in upslope portions of this population, which did not have significant disturbances that might introduce contamination (fig.1). Additional detections of multiple *Phytophthora* species near the reservoir high-water line appear to be

related to contaminated runoff and/or infected debris from landscaped urban development along the lakeshore about 1 km away.

Our baseline sampling indicated that *Phytophthora* infestations were generally uncommon in and near reserve system lands and infestations detected were mostly associated with known risk factors for *Phytophthora* introduction. Most *Phytophthora* detections were associated with common *Phytophthora* sources such as plantings of nursery stock, previous agricultural areas, and contaminated watercourses. Spread from these sources was associated with roads, trails, development and grading activities, livestock grazing, and overland water flow. Some detections were in disturbed areas where the likely source(s) of contamination were less clear, but *Phytophthora* was not detected in any of the relatively remote and undisturbed uplands that we sampled.

Management of the HCP/NCCP reserve system to minimize threats posed by *Phytophthora* should prioritize preventing introduction of additional *Phytophthora* species into habitat areas by excluding likely sources of contamination, such as infested nursery stock. Actions should also be undertaken to minimizing spread from existing infestations. *Phytophthora* management should be considered in conjunction with other management practices, such grazing, construction activities, and trail use. At some reserves, the season of grazing and the direction of livestock movement between pastures may need to be altered to minimize the risk of spreading contamination from known infestations. Additional research will be needed to guide adaptive management of *Phytophthora* infestations.

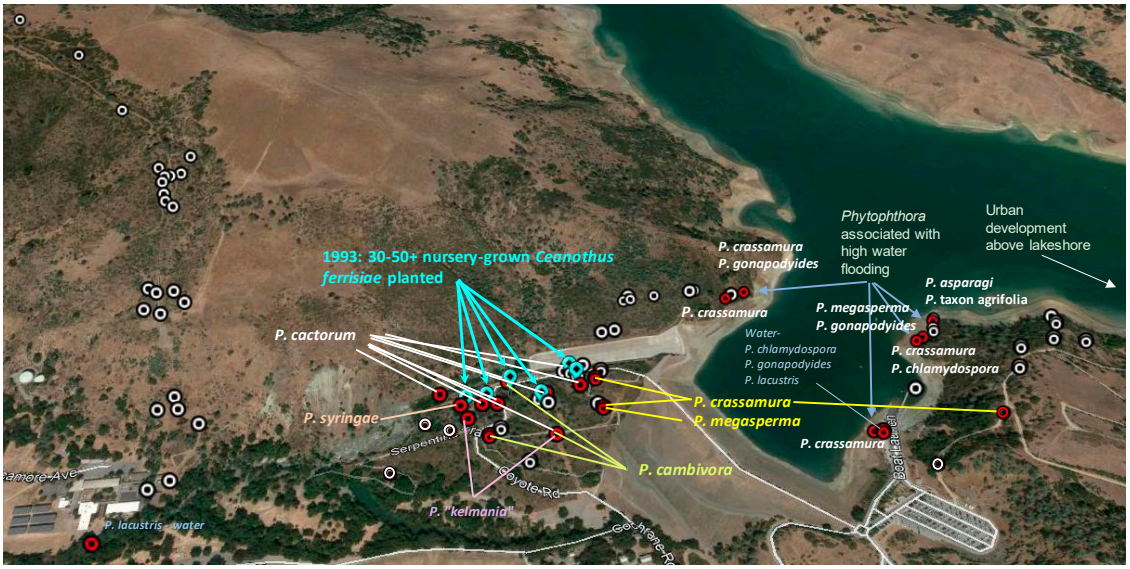

Figure 1—Results from soil and water samples collected in *Ceanothus ferrisiae* habitat near Anderson Lake as part of this and related projects. *Phytophthora* was detected (red symbols) in symptomatic plants on the dam abutment slope where nursery stock was previously planted and in plants along the lakeshore that were inundated briefly in winter 2016-17. White symbols are sample locations where *Phytophthora* was not detected.

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Literature Cited

Swiecki, T.J. and Bernhardt, E.A. 2018. Evaluating threats posed by exotic *Phytophthora* species to endangered Coyote ceanothus and selected natural communities in the Santa Clara NCCP area. Final report. Prepared for Santa Clara Valley Habitat Agency. 135p. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=161911. (12 February 2020).