

Phytophthora in Restoration and Forest Nurseries

by Laura Sims and Matteo Garbelotto

Diseases caused by *Phytophthora* are one of the most important problems for plant health in wildland and forest areas, especially following a rainy year. Specialized nurseries that grow plants for restoration and forest plantings play an important role in supplying healthy plants for these restoration and forest projects. Diseased nursery plants and infested potting soil with *Phytophthora* pathogens can be moved into wildland and forest areas and can subsequently become a source of new infections of other plant hosts. The long-term cost of managing diseases after these pathogens are introduced are much greater than preventing plants from becoming infected in the nurseries in the first place. Thus reducing *Phytophthora* in nurseries is a key strategy for protecting the health of wildlands, especially for those nurseries producing native plants. Without management and with conditions supporting disease, a high percentage of nursery plants could be a source of *Phytophthora* disease inoculum, as demonstrated in a survey conducted in Northern California nurseries where an average of 44% of native woody perennial plant crops were found to carry infections (Sims et al. 2017). These infections can potentially spread when outplanted to other sites, putting neighboring landscapes and plant communities at risk. Due to the lasting environmental and economic impacts these pathogens cause, many managers growing native plants in restoration nurseries are working on preventing *Phytophthora* diseases by implementing best management practices (Sims et al. 2016a). Managers of other types of nurseries are also encouraged to improve their practices for growing healthier plants. Preventing *Phytophthora* in the nursery not only protects landscapes and surrounding areas from disease when plants from the nursery are outplanted, it can also drastically reduce costs associated with fungicide use, reduce plant loss from disease, and can help nurseries meet the increasing standards of homeowners and agencies. Outlined herein is information on what *Phytophthora* is, prevention and management strategies to reduce the risk of *Phytophthora* in nursery stock, and some online resources.

What is Phytophthora?

Phytophthoras are worldwide-recognized plant pathogenic microorganisms that cause root and collar rot diseases of herbaceous and woody plants (Erwin and Ribeiro 1996). Additionally, some *Phytophthoras* infect aboveground plant parts and cause aerial diseases. Due to their ability to produce swimming spores and the importance of water in their lifecycle, *Phytophthoras* are often referred to as water molds: waterborne, these pathogens move and spread through infested water. They are also soilborne, spreading by the movement of infested soil, including soil stuck to tools, containers, or shoes. In addition to producing swimming spores, many *Phytophthora* species also produce thick-walled survival spores that can make disease eradication difficult once introduced to wildlands and urban planting areas.

Phytophthora infection begins with the release of swimming spores that move through the water. Root-rotting *Phytophthora* species, in particular, are attracted to plant root exudates. Once susceptible plant roots are infected, root-rotting *Phytophthora* species can degrade roots and cause disease that can spread upward into the root collar and sometimes the stems. Stem disease and infection of leaves (in *Phytophthoras* that cause aerial disease) can also be caused by direct contact, for example following water movement or splashing of infested water or soil. The sporangia or zoospores of aerial *Phytophthora* species may spread short distances in air currents or with wind-driven rain. Root-rotting *Phytophthora* species on the other hand, mainly spread through soil and water movement only. *Phytophthora* species cannot be seen with the naked eye unless grown in culture in a laboratory. However, if fungicides do not suppress *Phytophthora* disease development, it is often possible to see visible symptoms on host plants (fig. 1). These symptoms are described in detail in our next feature article in this newsletter.



Fig. 1. *Ceanothus thyrsiflorus* infested with *Phytophthora* sp. pathogens in a restoration nursery. Photo: Laura Sims.

There are over 100 described species in the genus *Phytophthora* and several of these can be a problem in nurseries. Additionally, hybrids and two new exotic species, *P. ramorum* and *P. tentaculata*, have been detected in nurseries, and these are especially of concern should they be introduced and spread to urban landscapes and wildlands.

Hybrid species may have an improved ability to cause disease when compared to parent type *Phytophthora* species. Nurseries provide an environment in which otherwise ecologically distant species that may be closely related have a chance to meet and reproduce.

P. ramorum, which causes sudden oak death, has already caused widespread mortality in native oaks and tanoaks in coastal areas of central and northern California and southwestern Oregon. First officially detected on rhododendrons in a Santa Cruz County nursery, it has since spread to 14 counties in California; it has also been detected in many other states and in British Columbia, and is widespread in European nurseries (Tjosvold et al. 2005; Tjosvold 2015).

P. tentaculata has recently been detected in several California native plant nurseries and restoration sites, and these are the first detections of *P. tentaculata* in the United States (Rooney-Latham and Blomquist 2014). *P. tentaculata* can cause root-rots, collar cankers, and stem cankers, which may result in the death of infected plants (Sims et al. 2016b), but it is unlikely to spread aerially as *P. ramorum* does. Managers of native and restoration nurseries must be on the lookout for these pathogens and implement best management practices to prevent the spread of new diseases.

Prevention and Management

Keep *Phytophthora* out of your nursery from start to finish by starting with healthy plant materials and maintaining sanitary conditions throughout the growing process. Start with healthy plant materials by using clean propagation practices and ensuring that plant material brought in from other nurseries is clean (Griesbach et al. 2012). Then, prevent plant exposure to *Phytophthora* during production phases by growing plants in clean media and containers, preferably on raised benches. Make sure to remove diseased crops. Only use clean tools and maintain proper irrigation practices throughout the life of the plant. If the nursery is involved in transporting nursery plants to the planting destination or to other nurseries, ensure that plants are moved without being exposed to pathogens in the process (sanitary truck bed).

Propagation. Seed is the preferred source of propagation material. This is because *Phytophthora* pathogens are often not transmitted by seed, so disease problems may be prevented if seeds are from a clean and healthy plant source. Avoid collecting seeds from the ground. Seeds that have soil or debris on them or are from an area where they could be immersed in site water could be contaminated with *Phytophthora*. If seeds must be collected following dissemination from the plant, then lay down a clean tarp, allow the plant to disperse seeds onto the tarp and retrieve seeds from the tarp only. Also, avoid collecting seeds from plants that appear unhealthy and use only a healthy source plant if it is necessary to propagate from cuttings. Treat low-growing seed collections and all cuttings with a fungicide dip following label protocol. All chemicals should only be applied following safe handling guidelines that are required by law and allow workers to use chemicals safely (CDPR handout 2016); it is always important to inform workers about the safe handling of chemicals and to post the safety data sheets (SDS) for the ones in use. It is of particular importance to keep propagation areas clean and sanitary and to do so safely. Use only clean (sanitized) tools and containers and pathogen-free root media in the propagation area. Organize your nursery so that propagation areas are away from potential sources of contamination.

Sanitation. All potting mix should be stored in original bags or in sanitized, covered containers until use. Reuse of media increases the potential of disease. Ground beds and potting mix that is reused should be treated. Even some new mixes, notably those containing peat, may benefit from treatment prior to use (Mathews and others 2014). UC IPM recommendations for managing *Phytophthora* are to steam (at 140°F for 30 minutes), solarize (double-tent at 160°F for 30 minutes or 140°F for 1 hour), or chemically treat growing media before use (Koike et al. 2009). Composting alone is not sufficient for killing *Phytophthora*, as is difficult to reach adequate temperatures evenly and for long enough to kill the pathogen in these systems.

Used containers should always be in good condition, cleaned, and sanitized before entering your nursery system. Proper disinfection of containers to eliminate *Phytophthora* and other pathogens (as well as killing most pathogens, pests and weed seeds) can be the difference between success and failure of containerized plants. First, wash containers to remove soil and debris. Then, disinfect containers by soaking in a 10% bleach solution for 30 minutes. (A 10% bleach solution can be made by adding one part standard household bleach containing 5-6% sodium hypochlorite to nine parts water.) Alternately, use aerated steam to disinfect containers by heating them to 180° F for 30 minutes (test container materials first to determine if they can withstand the heating process). Another option is to immerse washed containers in an 180° F hot water bath for 30 minutes.

Assume the ground in the nursery site is contaminated with *Phytophthora* and other pathogens. Avoid contamination from soil and debris by keeping plants and propagation materials elevated on an open-mesh bench, 3 to 4 feet above the ground, and discard any plants placed directly on the ground. Hang up hoses after use; do not let the hose nozzle or spray wand contact the soil to avoid transferring pathogens from the ground to growing areas. If the hose nozzle or spray wand is on the ground or becomes soiled, wipe it clean of debris and apply a disinfectant before using.

Collect, bag and remove crop residues; leaf debris; pruned plant material; and unhealthy and unmarketable plants in production areas on a regular basis. Place in a covered dumpster away from and downwind of healthy plants and production areas.

Disinfect propagation areas, greenhouses and shadehouses after every crop rotation. Use a power washer to remove all visible soil and debris, then spray surfaces with a disinfectant active against *Phytophthora*, such as alcohol (70%) or quaternary ammonium.

Clean and sanitize tools before and after use, using sets of tools designated for particular tasks. This can help to keep any breaches localized, making any necessary remediation simpler.

Exclusion/quarantine: When purchasing plant material from other nurseries, source from nurseries following best management practices for preventing *Phytophthora* and inspect incoming shipments to make sure plants are free from disease symptoms. One way to exclude *Phytophthora* is to quarantine new plants before incorporating them into the production system by placing them in a separate greenhouse or an isolated nursery area. (Exclusion is a mechanical control technique that consists of using barriers to prevent new pests and pathogens from entering an area.) Give the quarantined plants time (8 weeks) to develop symptoms in case fungicides or past conditions are inhibiting symptom development. If symptoms develop on plants in the quarantined area, dispose of the plant, soil and containers according to disposal guidelines for your area (e.g., there are specific CDFG disposal guidelines to be followed for *Phytophthora ramorum*); clean and sanitize benches.

Proper irrigation: Appropriate irrigation is extremely important for managing plant health and reducing the movement of *Phytophthora* from adjacent or nearby diseased areas in water. Practical strategies to improve irrigation include grouping plants in the nursery based on their watering needs, carefully watering to avoid splashing soil and water, and monitoring soil moisture levels. Start watering early (such as before dawn from 2 to 3 a.m.) to avoid prolonged leaf wetness and avoid overhead irrigation. Do not place emitters so that water sprays directly onto stems or foliage. Do not irrigate areas that are already wet because waterlogged soil can accelerate disease development. Also, do not stress plants by underwatering as this can predispose plants to disease. Instead, conserve water and promote plant health by scheduling irrigation based on local evapotranspiration or by installing soil moisture probes or tensiometers.

Provide regular maintenance of the irrigation system to maintain proper pressure; replace irrigation emitters and repair broken systems. Monitor irrigation water from any source other than a municipal water supply and test for waterborne pathogens at least bi-annually. Testing should be to confirm that the water is free from pathogens before use on plants or planting media.

Remediation. Plants that are exhibiting symptoms such as stunted growth and chlorotic foliage should be sent to a professional plant pathology laboratory for diagnosis, or in-field tests kits can be used. See our next feature article for a detailed discussion about plant symptoms and the identification

procedures for *Phytophthora*.

Discard unhealthy plants that are *Phytophthora*-infected, following local guidelines for disposal. Clean and sanitize the area where diseased plants are detected. Replace material beneath benches if they become contaminated.

In ornamental nurseries, economic losses due to *Phytophthora* are significant, and disease management typically includes the considerable use of fungicides. Plants in areas surrounding locations where pathogens have been confirmed are usually protected by using registered fungicides that are active on *Phytophthora* species (see UC IPM Guidelines listed in references). However, because fungicides suppress disease symptoms, chemical treatment can make early detection of the pathogen in monitoring programs more difficult, and cause detection problems. Moreover, concern has been raised that the use of fungicides in restoration and forest nurseries can result in infected plants that show no obvious symptoms being planted in wildlands. Then, as disease suppression declines and the chemicals degrade, the pathogens can resume activity, leading to both plant decline and infestation of the planting site (Working Group for Phytophthoras in Native Habitats 2016).

Online Resources

Two online resources were recently developed for managing *Phytophthora* in restoration, forest and native plant nurseries: *Presidio Phytophthora Management Recommendations* and *Guidelines to Minimize Phytophthora Pathogens in Restoration Nurseries*. Both online resources are included in the references below, along with other helpful resources (e.g., CalPhyos.org; [UC Berkeley Forest Pathology and Mycology Lab](#) website). It is recommended that growers consult these resources for more in-depth management guidelines. Additionally, the management practices and recommendations that are listed in these references can be used to design and execute a best management plan to meet the needs of your particular nursery and help you avoid future outbreaks of *Phytophthora*.

Sims is Postdoctoral Researcher in the Department of Environmental Science, Policy, and Management, UC Berkeley; M. Garbelotto is Extension Specialist in Forest Pathology and Adjunct Professor in the Department of Environmental Science, Policy and Management Department, UC Berkeley.

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