A new *Phytophthora* disease of native plants in California

by Thomas D. Landis

The following is a expanded discussion on this article from the New Nursery Literature section: # 113 - Rooney-Latham S, Blomquist C, Swiecki T, Bernhardt E, Frankel SJ. 2015. First detection in the US: New plant pathogen, *Phytophthora tentaculata*, in native plant nurseries and restoration sites in California. Native Plants Journal 16(1):23-26.

1. Introduction

Phytophthoras (the word means plant destroyers) are water molds — fungal-like organisms that are most closely related to brown algae. The genus *Phytophthora* is large, with over 100 described species, and disease symptoms include blights, cankers, dieback, wilts, root rots, and decline. Some Phytophthoras cause multiple symptoms on a single host, whereas other different symptoms on different hosts (Forest Phythophthoras of the World 2015). Host plants cover the entire gamut of propagated plants from agriculture, horticulture, and forestry. The most famous Phytophthora disease is the potato blight caused by *P. infestans* that devastated Ireland and lead to mass immigation during the mid-1800s. In forest and native plant crops, *P. ramorum* is responsible for the recent sudden oak death of forest trees and shoot and leaf blights in nurseries (Landis 2013a).

Phytophthora tentaculata is a relatively new plant pathogen that causes root and stem rot and was first isolated in 1993 from several floral species in a German nursery. Since then, it has been found on a wide variety of cultivated plants in Spain, the Netherlands, Italy and China. A Plant Epidemiology and Risk Analysis listed *P. tentaculata* as one of the top five Phytophthora species of concern due to potential environmental and economic impact (Frankel and others 2015). Phytophthora diseases are nothing new but what makes this pathogen notable is that it was first discovered in the US on native plants in California. Traditionally, native plants have been considered to be less susceptible to common nursery diseases, but this latest finding raises serious questions about that assumption.

This current infestation started in 2012 when *P. tentaculata* was discovered in a native plant nursery causing a severe root and crown rot in sticky monkey flower (*Diplacus aurantiacus*) (Figure 1). Subsequently, this pathogen has been confirmed on other native California forbs and shrubs including toyon (*Heteromeles arbutifolia*), coffeeberry (*Frangula californica*), and sage (*Salvia* spp.) Disease symptoms include root rot and stem cankers, resulting in wilting and eventual death of infected plants (Rooney-Latham and others 2015).

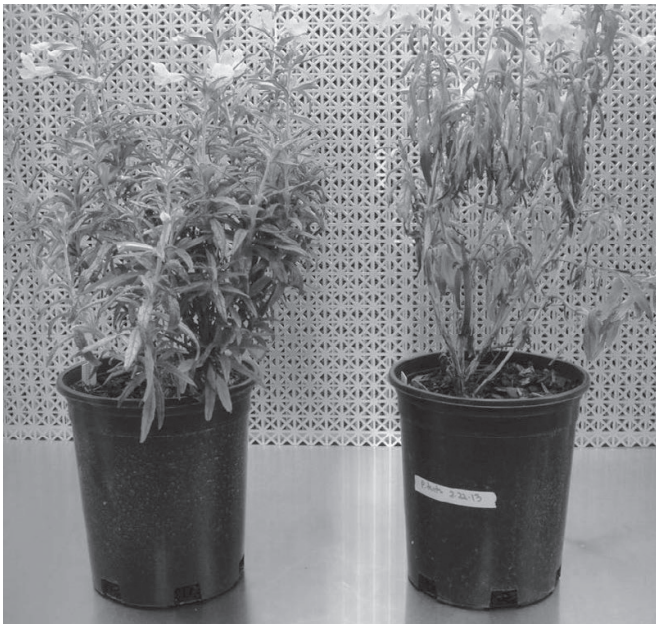

Figure 1 - Sticky monkey flower plants. Left: healthy. Right: Inoculated with Phytophthora tentaculata. *(Photo by Suzanne Rooney-Latham, California Department Department of Food and Agriculture).*

2. Transmission of *Phytophthora* on nursery stock

One of the major tenets of forest and native plant nurseries is that, because pests flourish in the favorable environmental conditions in the nursery, they will not survive in the harsher conditions on the planting site. Botrytis blight, caused by the fungus *Botrytis cinerea*, is a serious disease in the humid conditions in a container nursery and even thrives in the cold and dark of refrigerated storage (Landis and others 1990a). This fungus often can be found in the senescent foliage in the lower crown

Figure 2 - Phytophthora tentaculata *symptoms on outplanted sticky monkey flower. (Photo by Ted Swiecki, Phytosphere Research).*

of conifer seedlings in nurseries but cannot survive the dry conditions after outplanting. Opportunistic nursery pathogens, like Fusarium root rot (*Fusarium* spp.), can be isolated from the roots of asymptomatic plants but this is not considered as a reason to cull these seedlings (Peterson 2008).

What is worrisome about *P. tentaculata* is that it has been proven to be transmitted to several outplanting sites on infected container nursery stock (Frankel and others 2015). For example the pathogen was isolated from symptomatic sticky monkey flower plants on several outplanting sites in California (Figure 2). Recent investigations into the decline of reforestation plants in nurseries on restoration sites in the Bay Area of California have identified nine other *Phytophthora* species from symptomatic and asymptomatic native plants and nursery soil. Although pathogenicity has not been positively established, these findings strongly suggest that native plant nursery stock can transmit Phytophthora from the nursery to outplanting sites (Rooney-Latham and others 2015).

The destructive potential of nursery transmission of Phytophthora diseases has been shown with *P. ramorum* (Chastagner and others 2012). In the United Kingdom, nursery stock infected with this pathogen was found to be the cause of a devastating forest disease outbreak in a Japanese larch (*Larix kaempferi*) plantation where 3 million trees were killed (Brasier 2012). (For a more detailed discussion of *P. ramorum* in nurseries, see Landis 2013a).

3. Spread of *Phytophthora* diseases within a nursery: Learning from forest nurseries

I have been working with forest container nurseries for more than 30 years and, before this incident, had never seen a Phytophthora disease under modern cultural practices. In fact, in the Disease and Pest Management chapter of the Container Tree Nursery Manual, Phytophthora root rot is only mentioned when compacted growing medium is a problem (Landis and others 1990a). Let's look at some of the cultural practices that prevent Phytophthora from becoming a problem.

1. Seed propagation - Most forest, conservation, and native plants are propagated from seeds whereas many ornamental nurseries use liner stock produced at other nurseries. To my knowledge, Phytophthoras have never been spread on seeds whereas 15 different *Phytophthora* species were isolated from incoming nursery stock in a 3-year study in Maryland (Figure 3). Even more concerning was that most of the plants testing positive were asymptomatic. Certain genera of ornamental plants, including *Rhododendron* spp., *Pieris* spp., *Buxus* spp., and *Ilex* spp. were most commonly infected (Bienapfl and Balci 2014). So, from a disease prevention standpoint, seed propagation has a lot to offer and nurseries should be very careful about bringing liners or other transplants into their facilities.

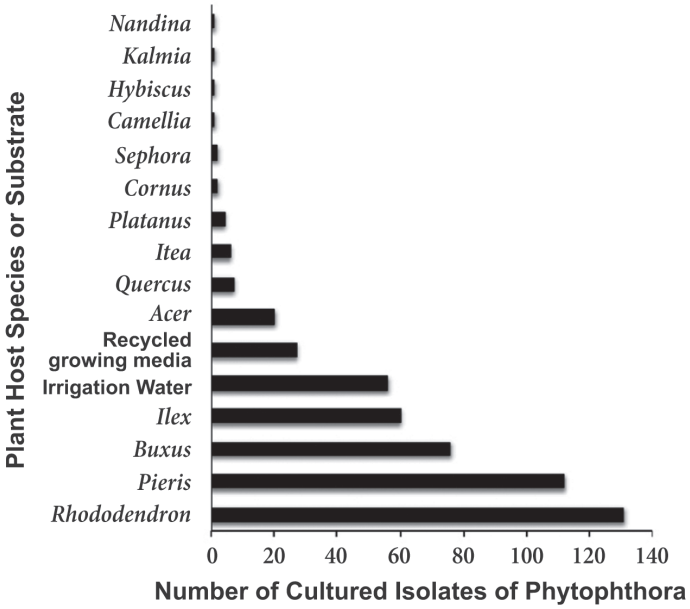

Figure 3 - Fifteen Phytophthora *spp. were isolated from numerous plant species and substrates in Maryland nurseries in 2010, 2011, and 2012 (modified from Bienapfl and Balci 2014).*

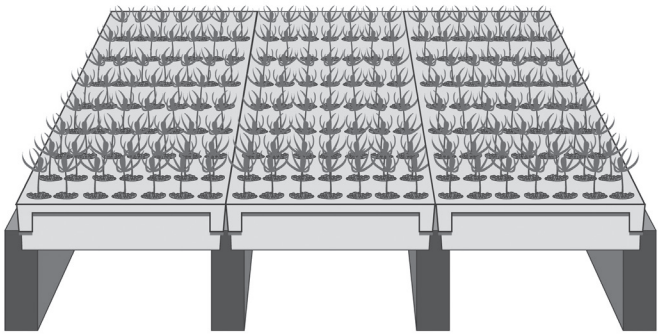

Figure 4 - Because Phytophthora tentaculata*, like all Phytophthoras, is mainly spread through water on nursery floors, the fact that forest nursery crops are grown in small containers on raised benches provides significant disease prevention.*

2. Small volume containers on raised benches - The average stocktype for forest tree seedlings is around 10 cubic inches (164 cc) and these containers are typically located on raised benches where they never come in contact with irrigation runoff (Figure 4). When larger containers are used, they are too heavy for benches and must be placed on the ground. In this situation, the possibility of transmission of waterborne pathogens like Phytophthoras is reduced when containers are placed on a thick layer of gravel to facilitate drainage.

3. Sterile growing media - Most forest nurseries grow their seedlings in completely artificial growing medium composed of some combination of *Sphagnum* peat moss, perlite, and vermiculite. Many of the root diseases common in early container culture including Phytophthoras could be traced to the native soil used in the growing media (Baker 1957). Inorganic growing media components such as vermiculite and perlite are sterilized by high temperatures during processing; however, peat moss and other organic components including composts can be contaminated with pathogens (Landis and others 1990b). Due to the increasingly high cost of peat moss and other traditional components, much research is going into alternative growing media using organic wastes and composts (Landis and Morgan 2009).

In a 3-years study of Maryland nurseries, contaminated growing media was second only to irrigation in cultural practices that spread Phytophthoras (Bienapfl and Balci 2014). To be completely safe, nurseries should consider treating all growing media and components; steam pasteurization has been shown to be effective against a wide range of pathogens in growing media, including *Phytophthora ramorum* (Table 1).

4. Overhead irrigation - Because all Phytophthoras produce motile zoospores, the cultural management of water is the most important disease control. In study of Maryland nurseries, irrigation water was the second only to imported nursery liners as a means of introducing *Phytophthora* spp. (Figure 3). Forest nurseries have traditionally used overhead sprinklers as the main irrigation method (Landis and others 1989). Crops are grown on raised benches are sprinkler irrigated are removed from the major source of *Phytophthora* infestation. All nurseries should have an irrigation management plan organized around best management practices. A systems approach is based on a hazard analysis of critical control points where waterborne pests could gain entry into your nursery (Parke and Grunwald 2012). These comprehensive programs that have been developed for ornamental nurseries can easily be modified for forest, conservation, and native plant facilities. Another approach is based on target pests. Nurseries should learn as much as possible about potential waterborne pests such as *Phytophthora* spp, and determine how, where, and when to test their irrigation water. A complete discussion of which pests can be spread in irrigation water, how to test irrigation water, and options for treating irrigation sources can be found in Landis (2013b).

Table 1 - Steam pasteurization of growing media at 122 °F (50 °C) for 30 minutes has been shown to be effective against soilborne pathogens (modified from Linderman and Davis 2008)

Soilborne pathogens	Recovery of soilborne pathogens (%)					
	Unheated	Temperature treatments for 30 minutes — °F (°C)				
		113 (45)	122 (50)	131 (55)	140 (60)	159 (65)
Cylindrocarpon scoparium	99	56	0	0	0	0
Phytophthora ramorum - Isolate A	77	0	0	0	0	0
Phytophthora ramorum - Isolate B	85	7	0	0	0	0
Pythium irregulare	98	23	0	0	0	0

4. Significance to the nursery industry

Phytophthora diseases have not been a serious concern in forest, conservation, and native plant nurseries, but the fact that the newest (*P. tentaculata*) and most potentially devastating (*P. ramorum*) diseases have been spread in surface water and contaminated growing media should make all nurseries reevaluate their cultural practices. As with all diseases, prevention is the key so managers should conduct a hazard analysis to learn how these pathogens could invade their nurseries. All nurseries want to maintain a good reputation for producing and selling healthy disease-free plants, so the fact that these new Phytophthoras have been shown to be transmitted on nursery stock to outplanting sites should serve as a wake-up call.

5. References

Baker KF, editor. 1957. The U.C. system for producing healthy container-grown plants. Berkeley (CA): University of California, Division of Agricultural Sciences, California Agricultural Experiment Station. Extension Service Manual 23. 331 p. URL:: https://archive.org/details/ucsystemforprodu23bake (accessed 28 Apr 2015).

Bienapfl JC, Balci Y. 2014. Movement of *Phytophthora* spp. in Maryland's nursery trade. Plant Disease 98:134–144.

Brasier C. 2012. EU2, A fourth evolutionary lineage in *P. ramorum*. Sudden Oak Death 5th Science Symposium. University of California, Division of Agriculture and Natural Resources. URL: http://ucanr.org/sites/sod5/Agenda/ (accessed 18 Aug 2012).

Chastagner G, Elliott M, McKeever K. 2012. Sudden oak death. In: Cram MM, Frank MS, Mallams KM. technical coordinators. Forest Nursery Pests. Washington (DC): USDA Forest Service. Agriculture Handbook 680: 135-137.

Forest Phytophthoras of the World. 2012. URL: http://www.forestphytophthoras.org/ (accessed 28 Apr 2015).

Frankel S, Swiecki T, Bernhardt E, Rooney-Latham S, Blomquist C. 2015. Pest Alert: *Phytophthora tentaculata*. Albany, CA: USDA Forest Service, Pacific Southwest Research Station. URL: http://www.suddenoakdeath.org/wp-content/uploads/2015/02/P.tentaculata.Pest_.Alert_.022315.pdf (accessed 10 Mar 2015).

Landis TD. 2013a. *Phytophthora ramorum*: Impacts on forest, conservation and native plant nurseries. Forest Nursery Notes 33(1): 15–24.

Landis TD. 2013b. Controlling pests that are spread in irrigation water. Forest Nursery Notes 33(2): 14–26.

Landis TD, Morgan N. 2009. Growing media alternatives for forest and native plant nurseries. In: Dumroese R.K, Riley LE, technical coordinators. 2009. National Proceedings: Forest and Conservation Nursery Associations—2008. Fort Collins (CO): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-58: 26–31.

Landis TD, Tinus RW, McDonald SE, Barnett JP. 1989. Volume 4: Seedling nutrition and irrigation. The Container Tree Nursery Manual. Washington (DC): USDA Forest Service. Agriculture Handbook 674. 119 p

Landis TD, Tinus RW, McDonald SE, Barnett JP. 1990a. Volume 2: Containers and growing media. The Container Tree Nursery Manual. Washington (DC): USDA Forest Service. Agriculture Handbook 674. 88 p.

Landis TD, Tinus RW, McDonald SE, Barnett JP. 1990b. Volume 5: The biological component: nursery pests and mycorrhizae. The Container Tree Nursery Manual. Washington (DC): USDA Forest Service. Agriculture Handbook 674. 171 p.

Linderman RG, Davis EA. 2008. Eradication of *Phytophthora ramorum* and other pathogens from potting medium or soil by treatment with aerated steam or fumigation with metam sodium. HortTechnology 18:106–110.

Parke JL, Grünwald NJ. 2012. A systems approach for management of pests and pathogens of nursery crops. Plant Disease 96: 1236–1244.

Peterson M. 2008. Fusarium species—a British Columbia perspective in forest seedling production. In: Dumroese RK, Riley LE, technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2007. Fort Collins (CO): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-57:109–125.

Rooney-Latham S, Blomquist C, Swiecki T, Bernhardt E, Frankel SJ. 2015. First detection in the US: New plant pathogen, *Phytophthora tentaculata*, in native plant nurseries and restoration sites in California. Native Plants Journal 16:23–26.