A Christmas Tree Grower's Guide to Sudden Oak Death (*Phytophthora ramorum*)

A number of conifers that are commonly grown as Christmas trees have recently been shown to be hosts of *Phytophthora ramorum*. This exotic, federally-quarantined plant pathogen causes Sudden Oak Death and *ramorum* shoot or leaf blight. Besides the direct damage this pathogen may cause on Christmas trees, federal and state restrictions on the movement of host plant material out of infested areas have the potential to significantly impact Christmas tree growers.

This guide provides practical information and advice on:

- The history of sudden oak death
- The susceptibility of conifers to *P. ramorum*
- The spread and development of *P. ramorum* in Christmas tree plantations
- Recognizing *P. ramorum*-like symptoms on conifers and other hosts
- Management considerations for protecting your plantation against *P. ramorum*
- Current quarantine regulations and staying informed
- Considerations when working in infested counties

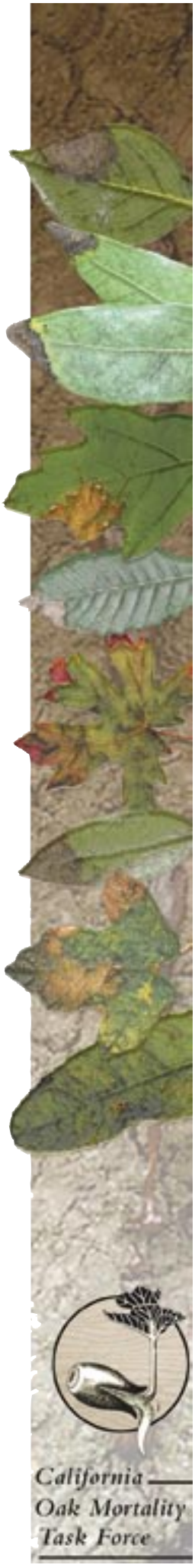
History of Sudden Oak Death

Symptoms of Sudden Oak Death were first reported from the central California coast in the mid 1990s. By 2000, the cause of this new disease was found to be a previously unknown *Phytophthora* species, which has since been named *Phytophthora ramorum*. In Marin, Santa Cruz, and Sonoma Counties, portions of the urban-wildland interface changed dramatically, as tanoak (*Lithocarpus densiflorus*), California black oak (*Quercus kelloggii*), coast live oak (*Q. agrifolia*), Shreve's oak (*Q. parvula var. shrevei*), and canyon live oak (*Q. chrysolepis*) tree crowns turned brown over a few weeks, giving the impression of a "sudden" death. Since then, *P. ramorum* has killed an estimated million susceptible oak and tanoak trees, and infected at least a million more in the central and northern California coastal area, as well as one county in southwest Oregon. To date, it is unclear where this exotic pathogen came from and by what means it was introduced to North America. Evidence suggests, however, that *P. ramorum* was brought into California through overseas commerce in the early 1990s. A different strain of this pathogen also appeared on ornamental plants in parts of Western Europe about the same time it appeared in California.

In addition to susceptible oak and tanoak, this organism has naturally infected more than 100 other plant species from 16 different plant families, including several species of conifers. Most of the non-oak and tanoak hosts develop leaf spots and/or twig dieback when infected by *P. ramorum*, and are not usually killed by the pathogen, but rather facilitate its spread. These diseases are commonly referred to as ramorum blight or dieback. Currently, the United States Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS) recognizes Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), white fir (*Abies concolor*), California red fir (*Abies magnifica*), coast redwood (*Sequoia sempervirens*), Pacific yew (*Taxus brevifolia*), and California nutmeg (*Torreya californica*) as proven or associated hosts of *P. ramorum*, making these native conifers subject to federal and state quarantines in regulated areas.

Christmas trees found to be infected with *Phytophthora ramorum*
Douglas-fir (*Pseudotsuga menziesii*)
Grand fir (*Abies grandis*)
White Fir (*Abies concolor*)
Red Fir (*Abies magnifica*)

As a result of the detection of *P. ramorum*-infected plants in California and Oregon wildlands, USDA APHIS restricts the movement of host



One pathogen, three diseases.		
Disease	Symptoms	Hosts
Sudden Oak Death	Bleeding cankers; tree death	Oak spp., tanoak
P. ramorum shoot blight	Shoot tip dieback	Coast redwood, Douglas-fir, evergreen huckleberry, true fir hosts, Pacific madrone, rhododendron, tanoak, poison oak, Pacific yew
P. ramorum leaf blight	Petiole and midrib necrosis; leaf spots with margins that look water soaked.	Bigleaf maple, California bay laurel, Cascara, California coffeeberry, rhododendron, wild rose, salmonberry, western starflower

material out of 14 quarantined coastal counties in California, from Monterey to Humboldt, and a small quarantined area of Curry County in southwest Oregon. Surveys conducted by natural resource agencies in California, Oregon, and Washington have not detected the pathogen in forests or Christmas tree plantations outside of the currently quarantined area.

In addition to its natural, localized spread via water droplets laden with spores, this pathogen has also been spread via the movement of infected plants to nurseries outside of the quarantined area. In these instances, steps have been taken to eradicate the pathogen from these nursery sites. Research has also shown that the pathogen can be carried from one area to another via the movement of contaminated soil. Because of the potential for this organism to spread into non-infested areas, causing additional die-off, and additional quarantines that restrict the flow of known hosts and associated hosts, it is important that Christmas tree growers keep up-to-date on current research, as well as federal and state regulations that apply to Christmas trees.

Conifer susceptibility to *P. ramorum*

Douglas-fir and coast redwood were identified as hosts of *P. ramorum* in 2002. In 2003, the pathogen was first found on Douglas-fir and grand fir Christmas trees in Santa Clara County, California. In 2005, *P. ramorum* was also detected on white fir and California red fir Christmas trees in Santa Clara County. In addition to these hosts that have been naturally infected under certain field conditions, laboratory research indicates that a number of conifers, particularly many true firs which are commonly grown as Christmas trees, may also be potential hosts of this pathogen.

Spread and development of *P. ramorum* in Christmas tree plantations

Limited information is available regarding the conditions necessary for the development and spread of this pathogen on conifers. Since 2005, research has been conducted at a Christmas tree site in Santa Clara County to provide insight into how this disease spreads on conifers and the risks this pathogen poses to plantings of Christmas trees. Infected Christmas trees at this site include Douglas-fir, grand fir, and California red fir. Data collected so far indicate that initial *P. ramorum* infection of Christmas trees occurs on susceptible tissue during precipitation events in the spring. Laboratory studies have shown that fairly high levels of inoculum (spores) are necessary for infection of Douglas-fir. Both laboratory and field research indicate that newly emerging shoots are only susceptible to infection for a few weeks following bud break. After initial infection of newly emerged shoots, dieback can progress for about a month as the pathogen spreads down the shoot into the previous year's growth, typically spreading only a few inches.

During wet periods, *P. ramorum* is known to produce copious amounts of spores from spots on infected leaves of epidemiologically-important (spore-producing) hosts such as California bay laurel. The spores are then carried by wind-driven rain to the foliage and bark of other susceptible hosts. The data from the California Christmas tree site has shown that there is little risk of infection to trees in a pure stand that are located five to eight meters from the edge of forests that contain epidemiologically-important hosts. Both field observations and laboratory studies indicate that after initial infection, Christmas trees probably act as dead-end hosts in that they do not produce inoculum on infected tissues.

P. ramorum symptoms on conifers and other hosts

The damage caused by *P. ramorum* on Douglas-fir and true fir hosts looks much like injury from a late frost or Botrytis tip blight (Photos 1-9). Initial infections occur on new growth in spring, during bud break and shoot elongation. After the initial infections, the pathogen causes the emerging shoot to wilt (Photos 1-4). The pathogen may continue to spread down the shoots resulting in a dieback. The extent of dieback varies by host and when infection occurs. When shoots are infected just after bud break, the pathogen commonly grows down the shoot into the previous year's growth. Often the needles on the previous year's growth are shed as the pathogen grows down the shoot, resulting in a dead shoot with a tuft of dead needles on the end (Photos 5-8). If infection occurs later, during shoot elongation, the pathogen may only cause a dieback of the newly developing shoot (Photo 9). Repeated infection may kill seedlings and saplings or greatly alter the growth and form of Christmas trees (Photo 8). Similarly, the foliage and small-diameter sprouts of coast redwood can be infected (Photo 10). Pictures of a wide range of symptoms caused by *P. ramorum* on conifers, including Douglas-fir, grand fir, white fir, California red fir, and coast redwood are available at the Washington State University Sudden Oak Death Education website (www.puyallup.wsu.edu/ppo/gallery/conifers/album/index.html). Because *P. ramorum* causes symptoms similar to those caused by other plant pathogens and abiotic conditions, samples must be sent to a lab for diagnosis. If you have trees that you believe may be infected with *P. ramorum*, contact your local county extension or agricultural commissioner's office, or state Department of Agriculture inspector to learn what to collect and how to submit samples to be tested.

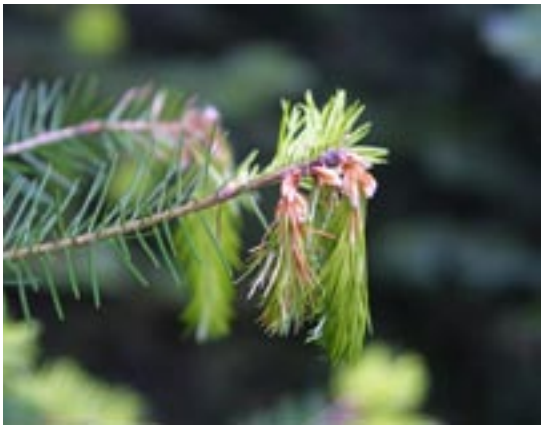


Photo 1. Tip dieback of Douglas-fir caused by *P. ramorum* in a California Christmas tree plantation. Photo: Gary Chastagner, WSU.

Photo 2. Tip dieback of grand fir caused by *P. ramorum* in a California Christmas tree plantation. Picture was taken in May shortly after infection following spring rainstorms. Photo: Gary Chastagner, WSU.

Initial infection of Christmas trees appears to result from the spread of spores from spore-producing hosts in the landscape surrounding plantings, making it important to be able to recognize symptoms on both conifer and non-conifer hosts. Symptoms caused by P. ramorum on hosts other than conifers can be dramatic, such as when it kills tanoaks (Photo 11), or fairly subtle, as in the case of California bay laurel (Photo 12) where symptoms consist of leaf spots that are often limited to the leaf tip. Symptoms on the various host plant species range greatly, from leaf spots to the death of mature trees. A complete list of host plants and additional pictures of symptomatic plants is available online at www.suddenoakdeath.org. If you are located in a regulated area and are adjacent to a wildland that contains symptomatic hosts, such as dying coast live oak, California black oak, and tanoak with bleeding cankers (Photo 13), and especially California bay laurel with leaf spots on the tips (Photo 12), trees in your planting are potentially at a higher risk of infection than if there are no known infected hosts in your area. California bay laurel is a good indicator plant to check for pathogen presence since it is often the first plant to show symptoms in a newly infested area.

Photo 3. Tip dieback of grand fir caused by *P. ramorum* in a California Christmas tree plantation. Spores produced on adjacent California bay laurel leaves during spring precipitation have infected most of the emerging shoot tips of this tree. Photo: Gary Chastagner, WSU.

Photo 4. Tip dieback of California red fir caused by *P. ramorum* in a California Christmas tree plantation. Photo: Kathy Riley, WSU.

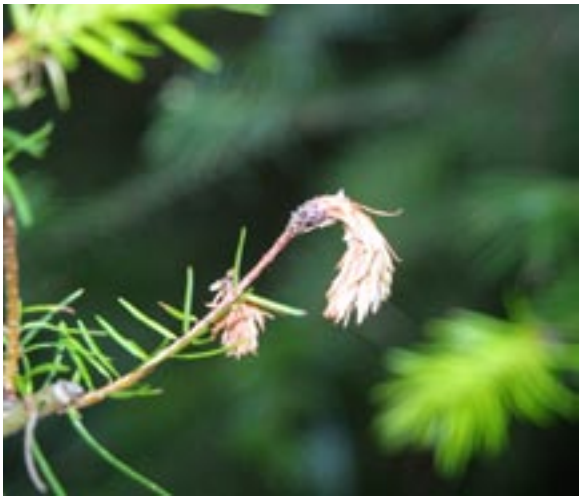


Photo 7. Tip and shoot dieback of Douglas-fir in a California Christmas tree plantation. Photo: Gary Chastagner, WSU.

Photo 5. Tip and shoot dieback of white fir caused by *P. ramorum* in a California Christmas tree plantation in Santa Clara County. The needles of this shoot readily fell off while rubbing the shoot between fingers. Photo: Kathy Riley, WSU.

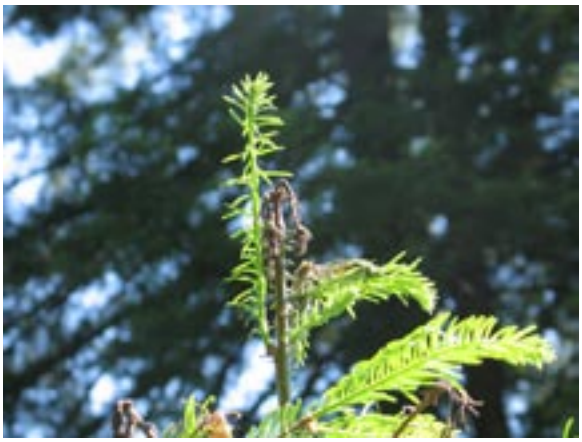


Photo 8. Ramorum dieback of the leader of this grand fir has altered the quality of this Christmas tree top. Infection occurred the previous spring. Photo: Kathy Riley, WSU.

Photo 6. Tip and shoot dieback of grand fir in a California Christmas tree plantation in Santa Clara County. The needles towards the ends of these shoots fell off naturally as dieback progressed from the infected shoot tips down the shoot into the previous year's growth during spring and early summer. Photo: Gary Chastagner, WSU.

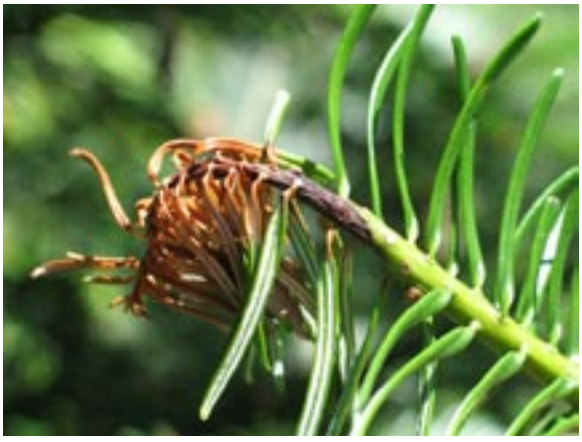


Photo 9: Grand fir with tip dieback caused by *P. ramorum*. Note that on this particular shoot, the pathogen has not spread far down the shoot into the previous years growth. Photo: Kathy Riley, WSU.

Management considerations to protect your plantation from *P. ramorum*

Photo 10: Foliar blight of coast redwood caused by *P. ramorum*. Photo: Kathy Riley, WSU.

One key to protecting your plantation from *P. ramorum* infestation is to monitor your plantings for symptoms of the disease. This requires that you spend some time learning to recognize symptoms of the pathogen. Instead of randomly selecting trees to examine, you should focus your examination to areas that are next to known hosts of *P. ramorum*. Because *P. ramorum* is only known to infect newly expanding shoots of Christmas trees, you should inspect your plantation in the spring during and just after shoot elongation.

In California, close proximity to California bay laurel or another spore-producing host appears to be necessary for infection of Christmas tree species. Thus, the perimeter of tree plantations should be inspected for the presence of California bay laurel and other hosts that could potentially serve as an inoculum source. Christmas trees grown under and adjacent to hosts in the surrounding landscape should be checked for *P. ramorum* symptoms. It is recommended that there be a border of at least 10 meters (33 feet) between the Christmas trees and the canopy of any potential inoculum source. Consider removing California bay laurel trees that border plantings of true firs (*Abies* spp.), Douglas-fir, or coast redwood if you are in an infested California county. If you sprinkler irrigate your plantations with water from streams or ponds, particularly in known infested areas, you should avoid irrigating your plantations during shoot elongation or you may want to consider treating your water to insure that it is not contaminated with *P. ramorum* spores.

Photo 11. Forest in Marin County with tanoak trees killed by *P. ramorum.* Photo: Janet Klein, Marin Municipal Water District.

Laboratory tests have shown that many of the fungicides that are commonly used to control various needle cast diseases on Christmas trees are also effective in protecting emerging conifer shoots from infection by *P. ramorum*. To be effective, fungicides have to be applied at bud break. Given that bud break often varies by species, from tree to tree, and even from one side of the tree to the other, it may be difficult to time fungicide applications. If you consider using fungicides, remember to read and follow all the instructions on the label.

Summary of current quarantine regulations and staying informed

In non-quarantine counties in California and Oregon, there are no quarantine restrictions on selling and shipping Christmas trees. In quarantined counties, Christmas trees can still be sold and moved, as long as they meet the same requirements as nurseries; known host and associated host plants must be inspected and found free of *P. ramorum* prior to export from the quarantined area. Quarantines have been enacted for the California counties of Alameda, Contra Costa, Humboldt, Lake, Marin, Solano, Sonoma, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, Mendocino, and Monterey, as well as the infested area in Curry County, Oregon. An Emergency Federal Order currently requires that all nurseries in California, Oregon, and Washington be inspected and found free of *P. ramorum* before they can ship any known host material interstate. This includes conifer seedlings.

If your farm is located in a quarantined county, contact your local agricultural commissioner or state Department of Agriculture inspector and arrange for your field to be inspected to obtain the necessary shipping permit. Restrictions and exceptions are provided on both the USDA APHIS and the California Department of Agriculture websites. Remember, it is important to check with your county agricultural commissioner on a regular basis to inquire about any changes in quarantine restrictions.

Considerations when working in infested counties

If you are working in a county where *P. ramorum* is known to be present in the landscape, as a precaution against spreading this pathogen:

• Inform crews about the implications of *P. ramorum* on Christmas tree plantations and sanitation practices when they are working in infested areas.
• Provide crews with sanitation kits that contain a disinfectant (Chlorine bleach [1/10 mixture bleach to water], Clorox Clean-up®, etc.), scrub brush, metal scraper, and plastic gloves.
• Clean and disinfect any tools after use on confirmed or suspected infected trees or in known infested areas.
• Sanitize shearing tools before cutting off healthy tree tips or working in pathogen-free areas.
• Use all reasonable methods to sanitize personal gear and crew equipment before leaving a *P. ramorum*-infested site. Scrape, brush and/or hose off accumulated soil and mud from clothing, gloves, boots and shoes. Remove mud and plant debris by blowing out or powerwashing chipper trucks, chippers, bucket trucks, fertilization and soil aeration equipment, cranes, and other vehicles.
• Avoid using contaminated water to irrigate trees.
• Use reasonable means to safeguard susceptible species while transporting them such as covering them with tarps or using a closed canopy truck.
• Report suspected cases of *P. ramorum* to the local county agricultural commissioner or Department of Agriculture inspector.
• Remember, before any known Christmas tree hosts can be moved out of a quarantined area, your field must be inspected so that you can obtain a permit.

Photo 12. California bay laurel leaves with leaf spots caused by *P. ramorum*. Note how the leaf spots are most prominent at the leaf tips. Photo: Gary Chastagner, WSU.

Resources on the web

• USDA-Animal & Plant Health Inspection Service (APHIS):
www.aphis.usda.gov/ppq/ispm/sod
• Sudden Oak Death Guide for Forest Managers:
www.puyallup.wsu.edu/ppo/pdf/P.%20ramorum%20Guide.pdf
• California Oak Mortality Task Force: www.suddenoakdeath.org

California
• California Department of Food & Agriculture (CDFA): www.cdfa.ca.gov
• UCCE offices statewide: danr.ucop.edu/danrdir/uccequery.cfm
• California Agricultural Commissioner's offices statewide:
www.cdfa.ca.gov/exec/cl/countyagmap.htm

Washington
• Washington State University's Sudden Oak Death Education Program:
www.puyallup.wsu.edu/ppo/resources.html
• Washington State Department of Agriculture:
agr.wa.gov/PlantsInsects/Diseases/SOD/default.htm

Oregon
• Oregon State University Extension:
extension.oregonstate.edu/emergency/oak_death.php
• Oregon Department of Agriculture:
egov.oregon.gov/ODA/PLANT/sod_free.shtml

Photo 13. Bleeding canker on a coast live oak trunk. Photo: Matteo Garbelotto, UC Berkeley.

Written by Gary Chastagner, Norm Dart, and Kathy Riley, Washington State University, Research and Extension Center, Puyallup, WA