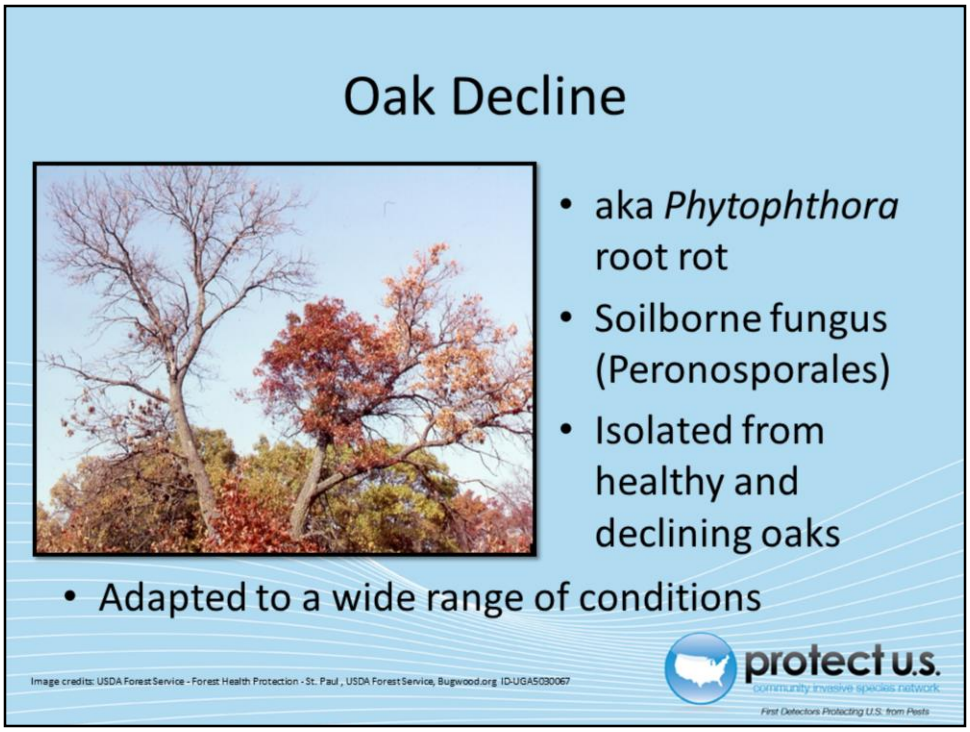
Oak Decline
Phytophthora quercina

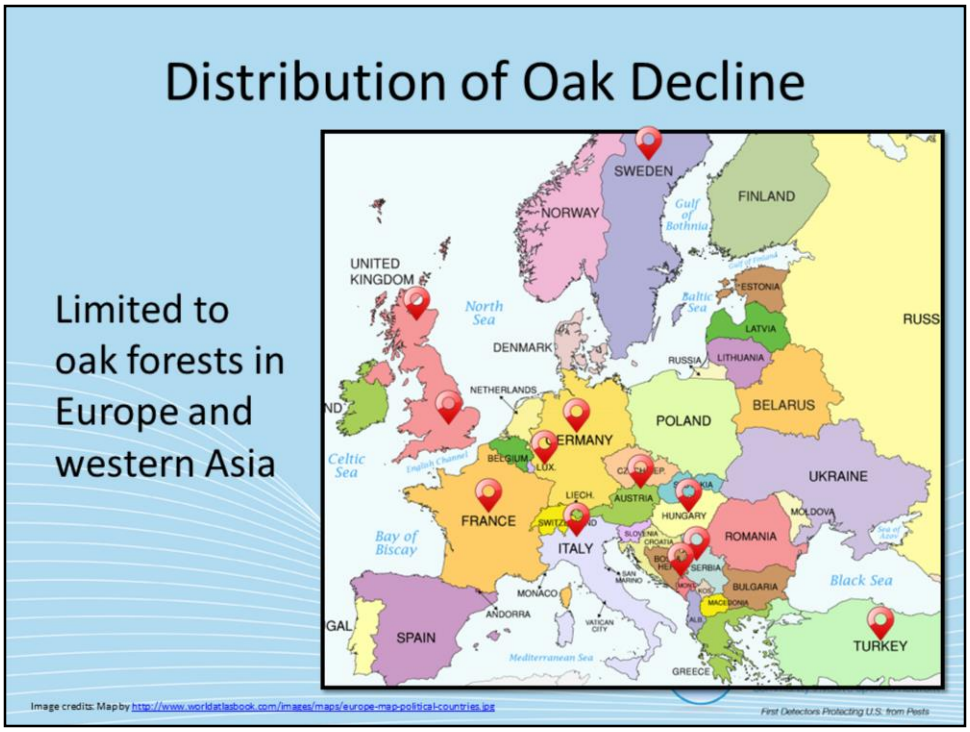


Oak Decline (*Phytophthora quercina*) is a soilborne root rot fungus belonging to Phylum Oomycota and Family Pythiaceae (14).

Since the 1980s, fluctuations in oak mortality occurred in Europe (16). At first the cause of the decline in European Oaks (*Quercus robur* and *Q. patraea*) remained unknown (16). However in the mid-1990s, several disease complexes, including a number of *Phytophthora* species were linked to the dieback scientists had been observing (16). A newly described species, *Phytophthora quercina*, was described by Jung et al. 1999 and is considered to be one of the primary causes of this 'oak decline' (16). The geographic origin of this pathogen remains unclear, however, populations analyses of *P. quercina* suggest that it was introduced to Europe and spread prolifically due to the lack of host diversity (6).

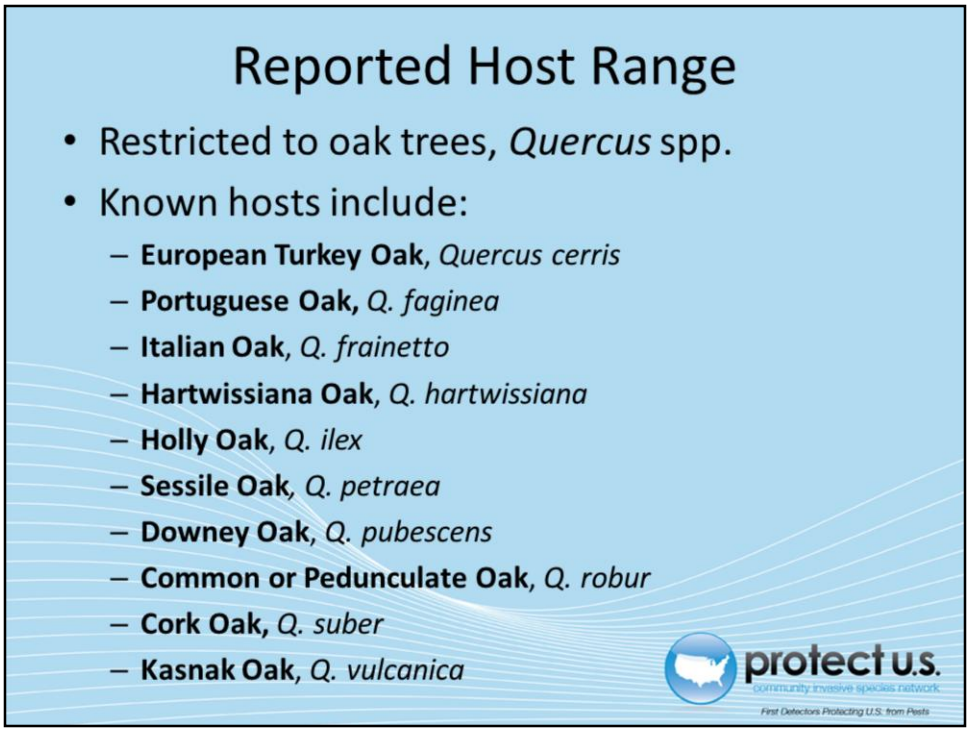
Since its discovery, *Phytophthora quercina*, has been isolated from European oaks that exhibit the characteristics of decline as well as those that are asymptomatic (1, 3, 11).

The pathogen is adapted to a wide range of temperatures and environmental conditions. However, optimal growth occurs between 22.5-25°C (72.5-77°F) in dry, nutrient rich clay or loamy soils with a more acidic pH of 3.5-7.0 (2, 5, 11, 12). High calcium and magnesium levels in the soil may also contribute to the pathogen's success (2).



The present known distribution of Oak Decline is limited to oak forests in Europe and western Asia (16). Countries where Oak Decline has been reported include those marked on the map (16):

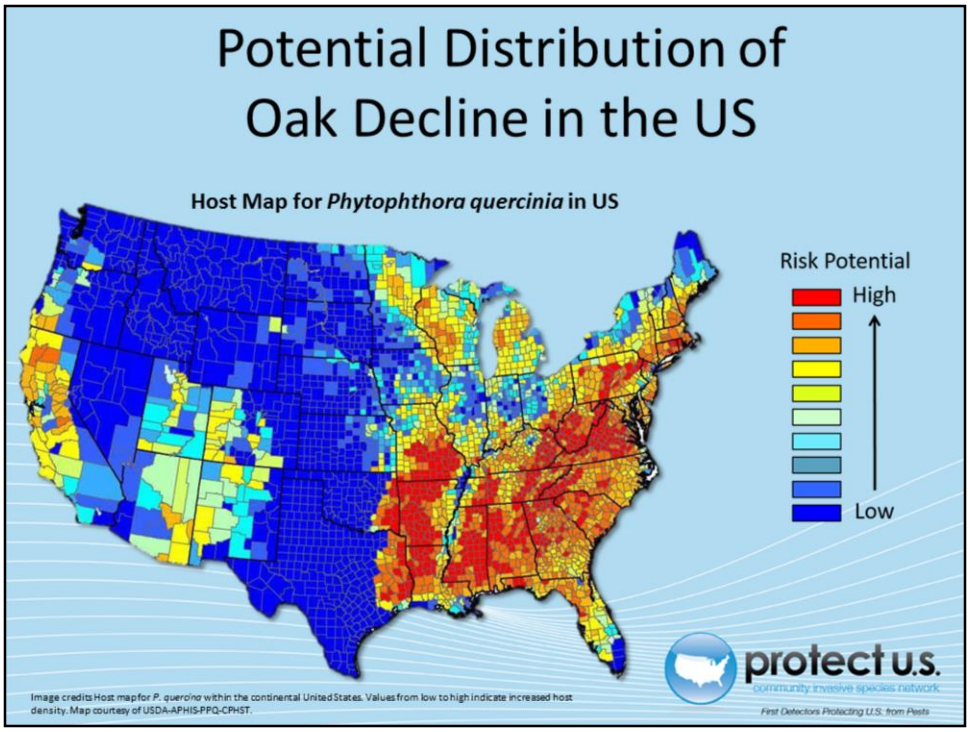
- Austria
- Belgium
- England
- France
- Germany
- Hungary
- Italy
- Luxemburg
- Serbia and Montenegro
- Scotland
- Sweden
- Turkey
- United Kingdom



Oak Decline has a narrow host range like other Group I *Phytophthora* species. True hosts appear to be limited to oak trees, *Quercus* spp., as infections in non-oak tree hosts have not yet been reported (12).

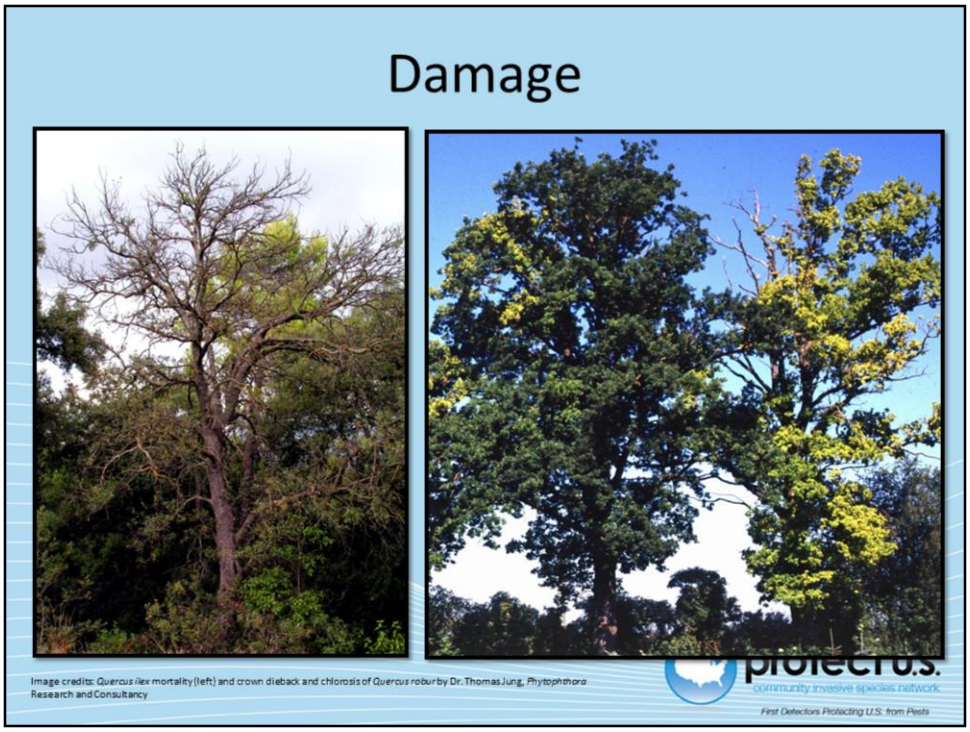
Documented hosts include (13, 17):

- **European Turkey Oak**, *Quercus cerris*
- **Italian Oak**, *Q. frainetto*
- **Hartwissiana Oak**, *Q. hartwissiana*
- **Holly Oak**, *Q. ilex*
- **Sessile Oak**, *Q. pubescens*
- **Common, Pedunculate Oak**, *Q. robur*
- **Kasnak Oak**, *Q. vulcanica*



Although a *Phytophthora quercina* 'like' organism was found in Minnesota, Wisconsin, and Missouri, molecular analysis separates isolates found in the United States from the Oak Decline pathogen of Europe (16). The abundance of possible host material and overall climatic similarities of U.S. with its current range in Europe, it is important to monitor oak forests for Oak Decline. The Mediterranean shrubland of California and the temperate broadleaf forests in the northeastern states may provide prime habitat for *Phytophthora quercina* (17).

The map featured here was developed by USDA-APHIS-PPQ-CPHST and illustrates host density of *Quercus* spp. within the contiguous U.S. Oak forest 'hot spots' are indicated by warm tones and low host density is represented by blue tones.

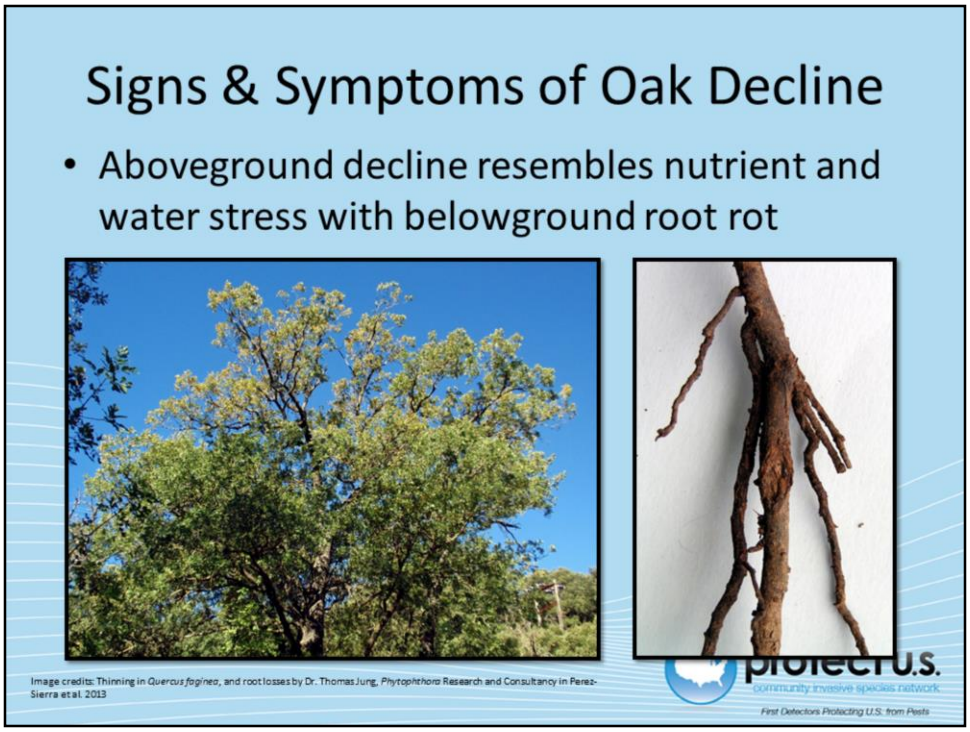


Oak Decline in Europe is often considered to be a mixture of many abiotic and biotic factors, therefore it is difficult to determine the extent of economic and environmental damage that can be solely attributed to *Phytophthora quercina*. Pathogenicity of *P. quercina* may be dependent on environmental conditions that predispose oaks to infection, such as drought or flooding, species diversity, and presence of additional pests or pathogens (17).

However, overall damage can be seen in aesthetically declining oak stands as well as reduced marketability of lumber. Annual oak mortality in Germany, partially caused by Oak Decline, has been estimated at 205 mature oaks per hectare, or approximately 1-2 oaks/ac (10).

Oak Decline is gradual and progressive occurring after several years with defoliation and dieback as primary symptoms. Within German and French nurseries, *P. quercina* is undetectable due to a short growing period (2-3 years) that does not allow for extensive development of belowground root damage and subsequent aboveground symptoms (16).

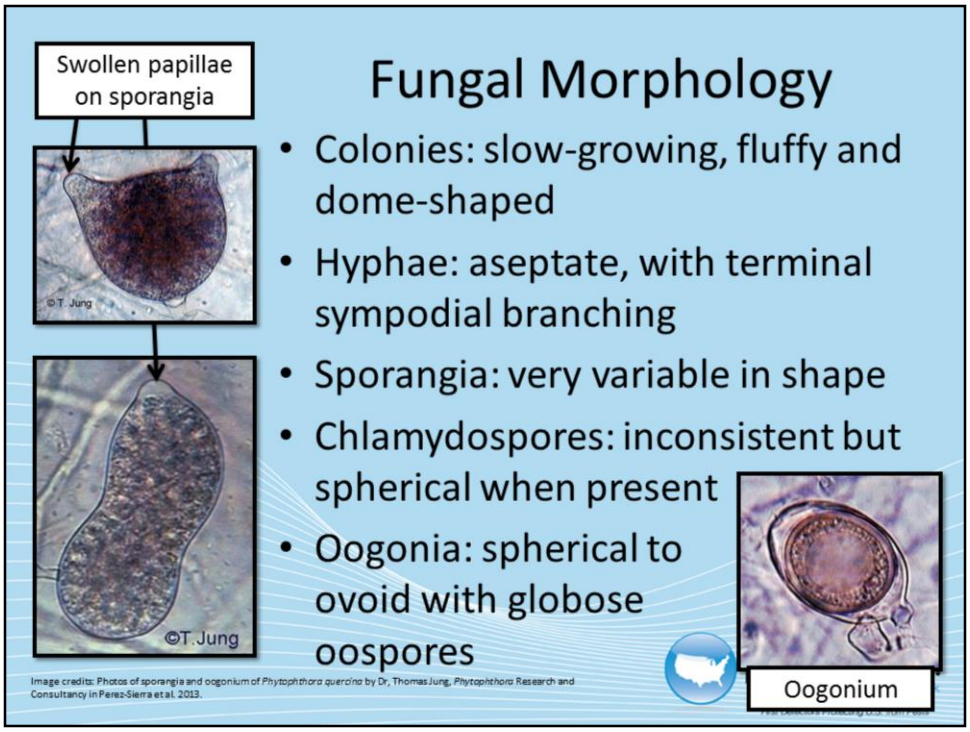
The image on the left is an example of an tree mortality of Holly Oak, *Quercus ilex*, and crown dieback and chlorosis in the Common/Pedunculate Oak, *Q. robur*, are seen on the right.



Symptoms of Oak Decline caused by *Phytophthora quercina* are difficult to distinguish from decline caused by other *Phytopthora* species in the field. Branch and crown dieback, epicormic shoots, and chlorotic and wilting leaves are common aboveground symptoms (17). Overall reduced growth can be associated with crown defoliation as well as necrotic and discolored feeder roots (17).

Lumber can be negatively affected with bark loosening, tylose formation, and discoloration of the sapwood (17). Tyloses form as plant defensive response involving the enlargement of parenchyma cells to block the spread of vascular pathogens in the xylem.

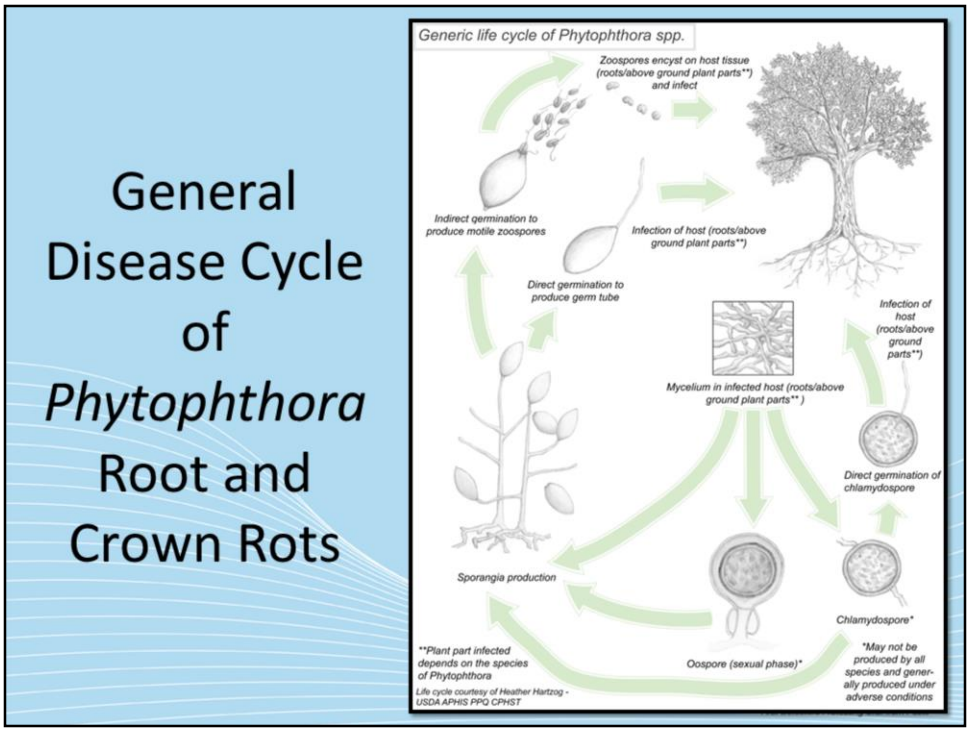
Tree death can be see in the image on the left and root loss on the right.



Morphological features of Phytophthora quercina vary considerably between individual specimens and accurate identification of the pathogen should be done with molecular analysis (12).

Colonies grown optimally at 20°C on malt extract agar or potato dextrose agar are fluffy and dome-shaped in appearance, becoming more flattened or appressed with maturity (12, 16). Hyphae are aseptate and exhibit terminal sympodial branching, meaning conidia develop on branches that arise at the ends or terminal growing points of the hyphae (9, 16). Sporangia of *P. quercina* have several different growth forms ranging from ovoid or globose to pyriform (pear-shaped) or ampulliform (flask-shaped) (16). The images on the left reveal two different sporangia forms – obpyriform and “banana- or peanut-like”. All sporangia have a swollen lump, papillae, indicated by the black arrows, along the edge.

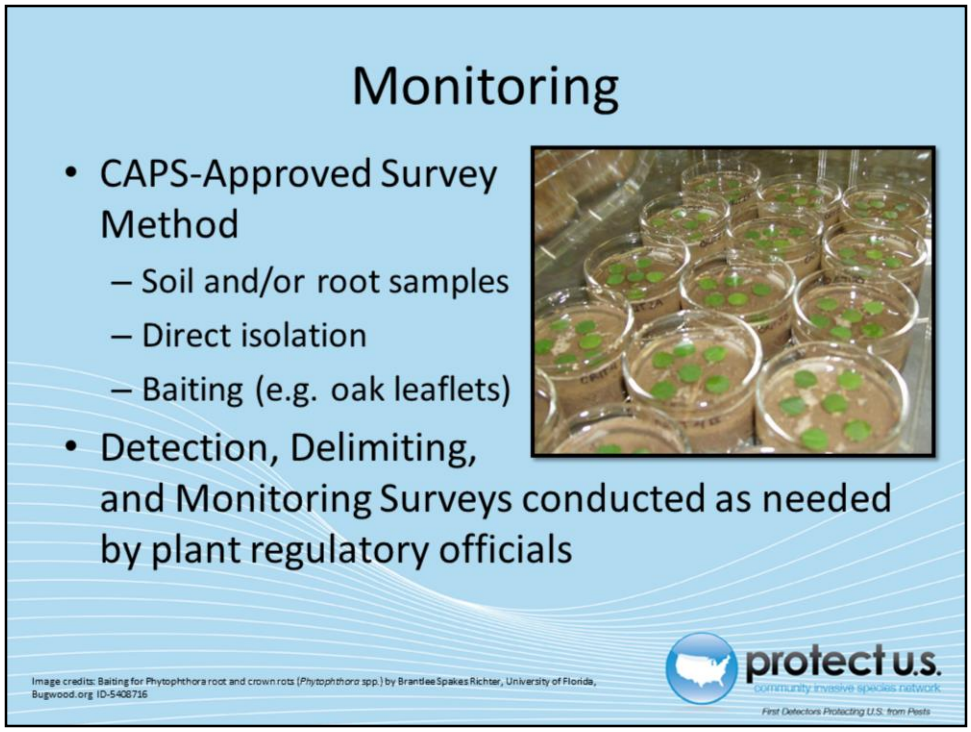
Chlamydospores are inconsistent produced, but when present they are spherical in shape (16). Oogonia are spherical to ovoid and generate globose oospores (16).



Since its discovery in 1999 by Jung *et al.*, little remains known or understood about the biology and epidemiology of *Phytophthora quercina* (16).

This diagram illustrates the general disease cycle of a typical *Phytophthora* spp. root rot.

Since *Phytophthora quercina* is a soilborne pathogen, dispersal is likely to occur as a result of contaminated logging machinery and planting material, as well as zoospore infested surface water. Soil particles can contain the oospores that have thick walls which allow them to withstand unfavorable conditions for multiple years including application of the fungicide metalaxyl (16).



Survey methods for isolating and identifying *Phytophthora quercina* are based on soil and/or root samples.

With direct isolation necrotic roots or bark cankers are rinsed, dipped in 95% ethanol for surface sterilization, and plated on semi-selective media (17). Active pathogen growth occurs within main roots after only a few days of initial infection of the fine roots (11, 12). The pathogen becomes dormant in the fine roots and greatly extends the germination process allowing selective media to become contaminated by other bacteria. It is necessary to obtain pure cultures for species confirmation utilizing morphological and molecular methods. Consequently, isolations from fine roots via baiting them with young oak leaves is considered the best method for this pathogen (11, 12).

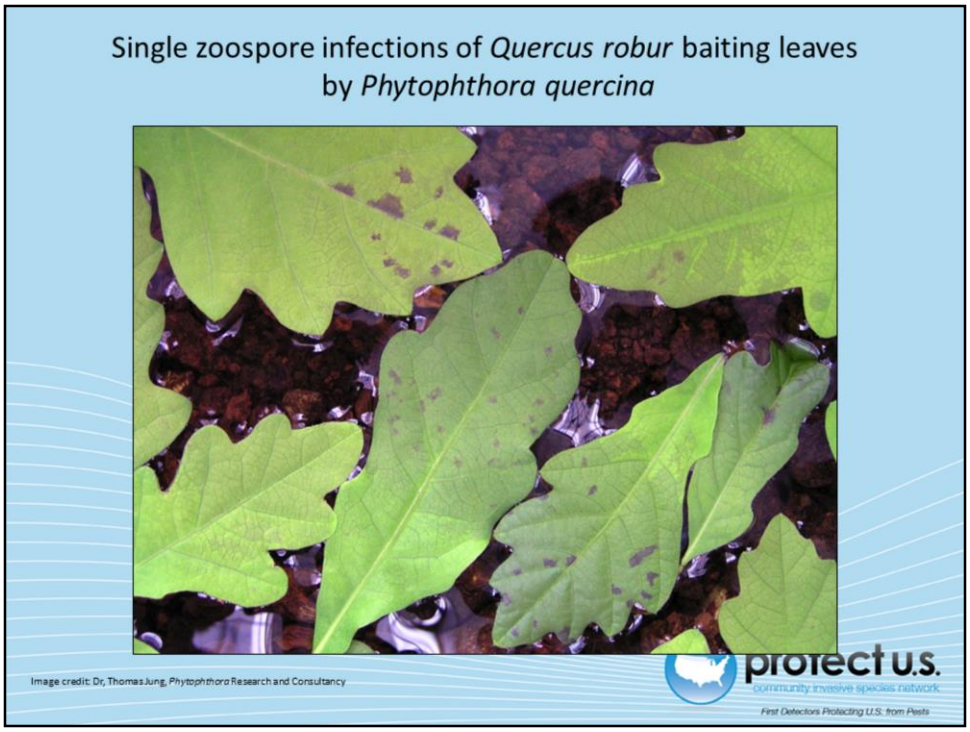
The Cooperative Agricultural Pest Survey (CAPS) approved survey method utilizes oak leaflet baits cut in a herring bone pattern and placed into a mesh bag submerged in a water-flooded soil sample (17). Bait is removed after 48 hours and observed for lesions after 1 week (17). The photo on the right is an example of rhododendron leaf baiting and isolation for other *Phytophthora* spp. conducted at the University of Florida. Zoospores are attracted to leaves and can disperse through the water to cause decay in the bait. Following infection, the bait is rinsed surface sterilized and plated (17).

Soil-root samples may be collected from symptomatic trees and visually surveyed from different stages of decline (17). The soil can then be baited, flooded, and dried at room temperature to isolate *Phytophthora* (11).

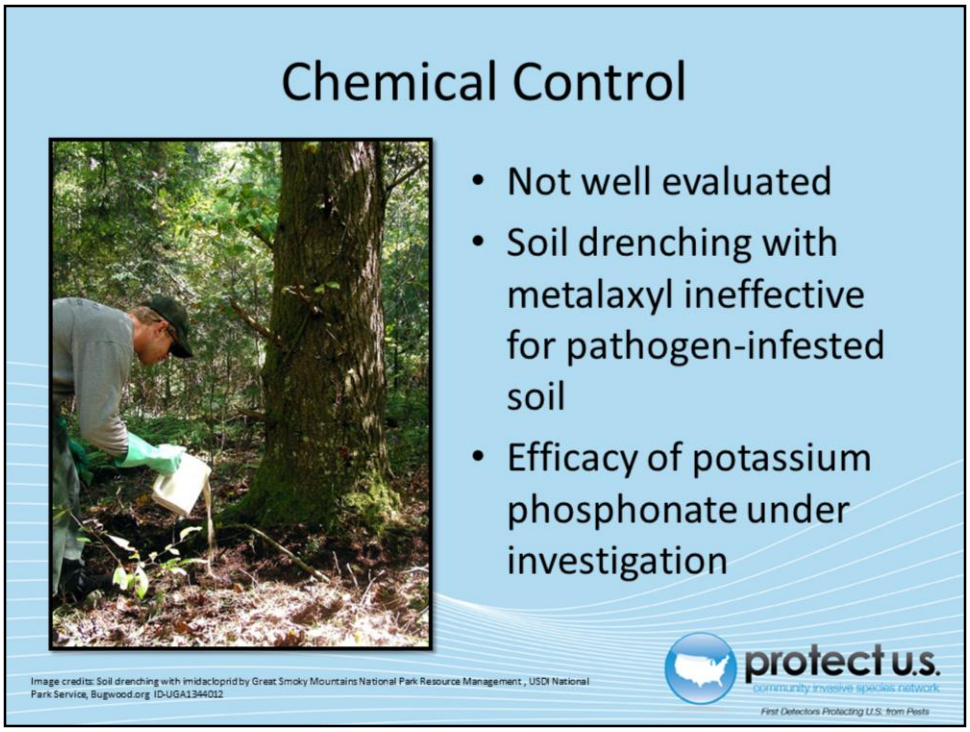
Detection Surveys are used to determine whether or not Oak Decline is present in an area in which it was previously not known to occur. Detection Surveys may be broad in scope and consider multiple pests/pathogens or they may be more restricted to a smaller area where a pest has potential to occur (16). However, it is important to note that a negative Detection Survey does not necessarily guarantee the absence of a pest or disease.

If a new detection is confirmed in the US, or if a detection in a new area where the pest was not previously found is confirmed, regulatory officials will form a Technical Working Group (TWG) to outline the procedure for conducting a Delimiting Survey (16). Delimiting Surveys define the extent, geographic range, and possible rate of spread of the newly detected disease (16).

After regulatory officials determine any necessary and appropriate control options, implementation follows. Monitoring Surveys are used to measure the effectiveness of control efforts (16).

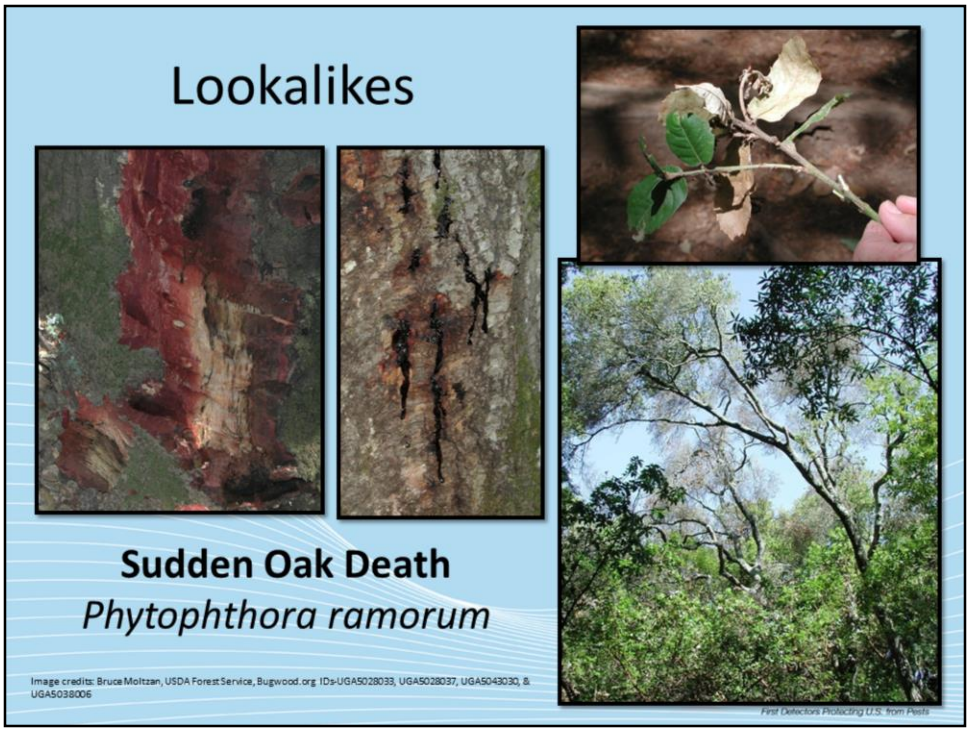


The image here illustrates the single zoospore infection of *Phytopthora quercina* which generates lesions on *Quercus robur* baiting leaves.



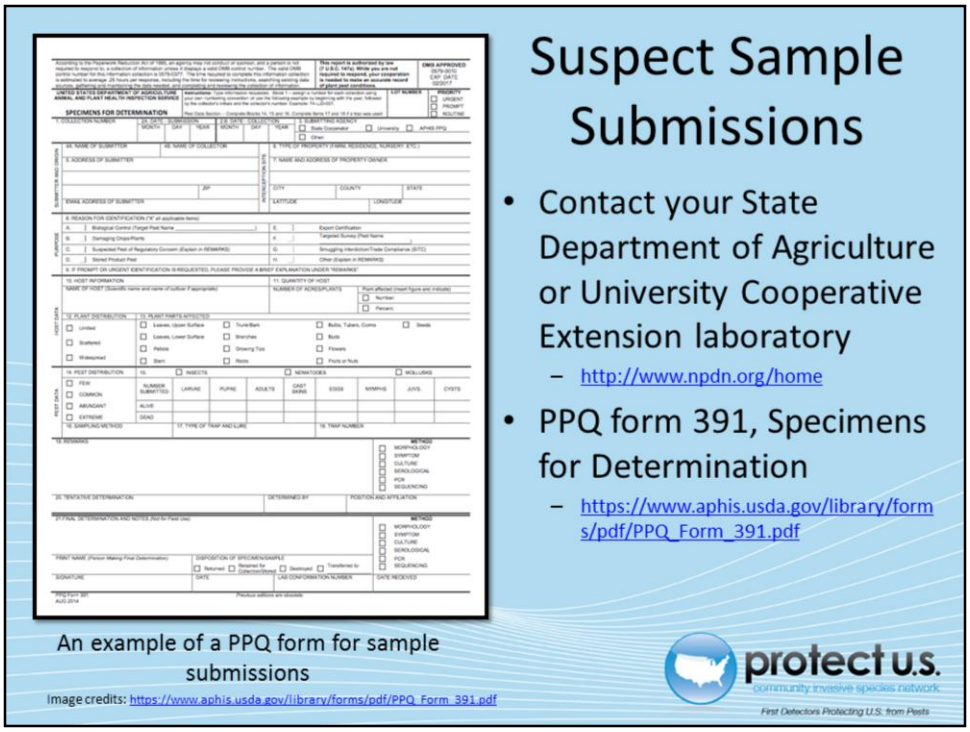
Chemical control options for *Phytophthora quercina* have not been well evaluated. Due to the survival stage (oospores) soil drenching with the fungicide metalaxyl has proven to be an ineffective treatment method for pathogen-infested soil (16). Soil drenching is a common technique used for both systemic application of insecticides, as seen in the photo on the left, and fungicides. Another potential fungicide control option under investigation is potassium phosphonate (16).

As with any disease management plan, moisture management, sanitation, and maintaining host vigor is important for suppressing pathogen populations. Monitoring and testing any source of untreated irrigation water in a nursery setting is important along with minimizing the presence of standing water and use of overhead irrigation (16). Disinfecting machinery, equipment, planting material, nursery stock, and personnel can help reduce the likelihood of spreading the pathogen throughout an area (16). Avoiding host injury during planting and maintenance, especially to the roots, can prevent entry sites for *Phytophthora* as well as other disease agents (16). Drought stress has been known to play a role in infection by root rot diseases and should also be avoided. Scientists also propose that lowering soil pH may reduce nursery bed populations of *P. quercina* (11). Other general cultural practices for Oak Decline management include nursery tree species rotation and heating or steaming the soil, a practice commonly used for other soilborne pathogens (16).



Since species identification is dependent on molecular analysis, aboveground symptoms and morphology of *Phytophthora quercina* may be confused with other *Phytophthora* species occurring in oak.

Sudden Oak Death, *Phytophthora ramorum*, is an example of a disease affecting oaks in the United States. Sudden Oak Death produces similar dieback, decline, and trunk canker symptoms (8). Other common symptoms include: discolored leaves with lesions, 'bleeding' cankers, and vascular discoloration (8).



If a suspect pest has been located in the United States, a sample should be submitted for proper identification. Contact your local diagnostic lab to ship in a sample for identification. Information regarding your local diagnostic lab is available at National Plant Diagnostic Network (NPDN) website. The diagnostic lab information and available contacts are divided by state.

http://www.npdn.org/home

The sample specimen should be submitted along with accompanying documentation using the PPQ form 391.

https://www.aphis.usda.gov/library/forms/pdf/PPQ_Form_391.pdf

Your local diagnostic lab is part of your local cooperative extension service or your state department of agriculture. Your local lab will also have a specific form. All local labs may not be a member of NPDN. However, all labs should report new pest and pathogen detections to local regulatory officials.

Remember that new pest and pathogen records must be reported to your State Plant Health Director (SPHD) and your State Plant Regulatory Official (SPRO). The SPRO is a State Department of Agriculture Employee and the SPHD is a USDA-APHIS-PPQ employee.

The link to your SPRO is on the National Plant Board (NPB) website. It has an interactive map and when you click on your state it will take you to another page with contact information. The NPB is a cooperative organization that includes membership from all State Departments of Agriculture.

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References

1. Balci, Y. and E. Halmschlager. 2002. First confirmation of *Phytophthora quercina* on oaks in Asia. *Plant Dis*. 86(4): 442. Accessed 7/25/16.
   - http://apsjournals.apsnet.org/doi/abs/10.1094/PDIS.2002.86.4.442C
2. Balci, Y. and E. Halmschlager. 2003a. *Phytophthora* species in oak ecosystems in Turkey and their association with declining oak trees. *Plant Pathol*. 52: 694-702. Accessed 7/25/16.
   - http://onlinelibrary.wiley.com/doi/10.1111/j.1365-3059.2003.00919.x/epdf
3. Balci, Y. and E. Halmschlager. 2003b. Incidence of *Phytophthora* species in oak forests in Austria and their possible involvement in oak decline. *Forest Pathol*. 33(3): 157-174. Accessed 7/25/16.
   - http://onlinelibrary.wiley.com/doi/10.1046/j.1439-0329.2003.00318.x/pdf
4. Balci, Y., and E. Halmschlager. 2003c. First report of *Phytophthora quercina* from oak forests in Austria. *Plant Pathol.* 52(3): 403. Accessed 7/25/16.
   - http://onlinelibrary.wiley.com/doi/10.1046/j.1365-3059.2003.00825.x/pdf

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References

5. Barzanti, G. P., P. Capretti, and A. Ragazzi. 2001. Characteristics of some *Phytophthora* species isolated from oak forest soils in central and northern Italy. *Phytopathol. Mediterr.* 40: 149-156.
   - http://www.fupress.net/index.php/pm/article/view/1594/1529
6. Cooke, D.E.L., Jung, T., Williams, N.A., Schubert, R., Oßwald, W., and Duncan, J.M. 2005. Genetic diversity of European populations of the oak fine-root pathogen, *Phytophthora quercina*. *Forest Pathol.* 35(1): 57-70. Accessed 7/25/16.
   - http://onlinelibrary.wiley.com/doi/10.1111/j.1439-0329.2004.00384.x/epdf
7. Davis, E. E., R. C. Venette, and E. M. Albrecht. 2010h. Oak commodity based survey. USDA-APHIS-PPQ-CPHST-CAPS. 1-298 pp. Accessed 6/15/16.
   - http://download.ceris.purdue.edu/file/604
8. Harmon, P.F. and C.L. Harmon. 2004. (Revised 2014). Sudden Oak Death and Ramorum Blight. Plant Pathology Department, UF/IFAS Extension. EDIS Publication: PP197. Accessed 7/25/16.
   - http://edis.ifas.ufl.edu/pp118

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References

9. Hawksworth D.L., P.M. Kirk, B.C. Sutton, and D.N. Pegler. 1995. Ainsworth & Bisby's Dictionary of the fungi. International Mycologyical Institute.
10. Heiser, I., J. Fromm, M. Giefing, J. Koehl, T. Jung, and W. Osswald. 1999. Investigations on the action of *Phytophthora quercina*, *P. citricola* and *P. gonapodyides* toxins on tobacco plants. Plant Physiology & Biochemistry. 37(1): 73-81. Accessed 7/25/16.
    - http://www.sciencedirect.com/science/article/pii/S0981942899800692
11. Jung, T., H. Blaschke, and W. Osswald. 2000. Involvement of soilborne *Phytophthora* species in Central European oak decline and the effect of site factors on the disease. *Plant Pathol*. 49: 706-718. Accessed 7/25/16.
    - http://onlinelibrary.wiley.com/doi/10.1046/j.1365-3059.2000.00521.x/epdf
12. Jung, T., D.E.L. Cooke, J. Blaschke, J.M. Duncan, and W. Obwald. 1999. *Phytophthora quercina* sp. nov., causing root rot of European oaks. *Mycol. Res*. 103 (7): 785-798. Accessed 7/10/16
    - http://journals.cambridge.org/abstract_S0953756298007734

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References

13. Jung, T., L. Orlikowski, B. Henricot, P. Abad-Campos, A.G. Aday, O. Aguín Casal, J. Bakonyi, S.O. Cacciola, T. Cech, D. Chavarriaga, T. Corcobado, A. Cravador, T. Decourcelle, G. Denton, S. Diamandis, H.T. Doğmuş-Lechtijärvi, A. Franceschini, B. Ginetti, S. Green, M. Glavendekić, J. Hantula, G. Hartmann, M. Herrero, D. Ivic, M. Horta Jung, A. Lilja, N. Keca, V. Kramarets, A. Lyubenova, H. Machado, G. Magnano di San Lio, P.J. Mansilla Vásquez, B. Marçais, I. Matsiakh, I. Milenkovic, S. Moricca, Z.Á. Nagy, J. Nechwatal, C. Olsson, T. Oszako, A. Pane, E.J. Paplomatas, C. Pintos Varela, S. Prospero, C. Rial Martínez, D. Rigling, C. Robin, A. Rytkönen, M.E. Sánchez, A. V. Sanz Ros, B. Scanu, A. Schlenzig, J. Schumacher, S. Slavov, A. Solla, E. Sousa, J. Stenlid, V. Talgø, Z. Tomic, P. Tsopelas, A. Vannini, A.M. Vettraino, M. Wenneker, S. Woodward, and A. Peréz-Sierra. 2016. Widespread *Phytophthora* infestations in European nurseries put forest, semi-natural and horticultural ecosystems at high risk of *Phytophthora* diseases. *Forest Pathol*. 46: 134-163. Accessed 8/3/16.
   – http://onlinelibrary.wiley.com/doi/10.1111/efp.12239/epdf

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References

14. Mycobank. 2016. Accessed 7/29/16.
    - http://www.mycobank.org/MB/460046
15. Pérez-Sierra, A., C. López-García, M. León, J. García-Jiménez, P. Abad-Campos, and T. Jung. 2013. Previously unrecorded low-temperature *Phytophthora* species associated with *Quercus* decline in a Mediterranean forest in eastern Spain. *Forest Pathol*. 43: 331-339. Accessed 7/30/16.
    - http://onlinelibrary.wiley.com/doi/10.1111/efp.12037/epdf
16. USDA-APHIS. 2010. *Phytophthora* species in the Environment and Nursery Settings New Pest Response Guidelines, USDA-APHIS-PPQ-Emergency and Domestic Programs–Emergency Management, Riverdale, Maryland. Accessed 7/25/16.
    - https://www.aphis.usda.gov/import_export/plants/manuals/emergency/downloads/nprg-genericphytophthoras.pdf
17. USDA-APHIS-PPQ-CPHST-CAPS. Datasheet: *Phytophthora quercina*
    - http://download.ceris.purdue.edu/file/2962

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