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PLANT MATERIALS TECHNICAL NOTE

Sudden Oak Death (SOD)

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Introduction: A new and serious disease of oak species (*Quercus*) and tanoak (*Lithocarpus densiflorus*) known as Sudden Oak Death (SOD) has recently emerged on the west coast of the United States. Although currently confined to California and an isolated location in Oregon, the seriousness of the disease and its possible spread among oak and other species within and outside of its current zone of infestation warrants concern. Plant Materials Specialists, Center Managers, staff, and NRCS Field Office personnel should be aware of this disease, able to identify its symptoms by plant host, and be able to directly or indirectly initiate control measures. Staff in regions of the country characterized by mild, moist winters should be particularly alert. Staff should be aware of local, state, federal, and international regulations restricting the movement and transport of host plants, plant parts (wood, leaves, fruit, seed), and soil.

I. ORIGIN: Sudden Oak Death is caused by a highly contagious fungus-like plant pathogen (water mold) named *Phytophthora ramorum*. It was first identified in Europe in 1993 as the causal agent of a disease appearing on the leaves and branches of ornamental rhododendrons, but not affecting European oaks. The same disease was identified in 1995 as the pathogen causing mortality in oaks in California. There are approximately 60 known *Phytophthora* that are closely related to *P. ramorum* (1). For the purposes of this Technical Note, SOD will be used synonymously with infection by *P. ramorum*.

II. CURRENT ZONES OF INFESTATION: As of September 4, 2002, SOD has been confirmed by laboratory isolation in twelve counties in California, and reported in several others (2). It was first reported in Marin County, California, in 1995. It has been reported in a 190-mile range from Sonoma Valley in the north to Big Sur in the south, as well as east to the Napa County border, approximately 25 miles inland (1). Sudden Oak Death has also been confirmed in 9 isolated spots in southwestern Oregon and is currently considered confined to its original 9-square-mile control area in Curry County (2, 3).

Outside of the United States, SOD has been confirmed in Germany and The Netherlands. There are reports of SOD infection of a limited number of viburnum nursery stock in Great Britain as well. Those plants are said to have been destroyed; and Great Britain is taking measures to prohibit the importation of known host plants, and oak wood, from areas of the US known to be infested with SOD (3).

III. POTENTIAL ZONES OF INFESTATION: It is likely that SOD will continue to spread among susceptible species in California and Oregon when not treated. Areas of the US supporting susceptible species and having climates similar to coastal California and Oregon are potentially at risk. A nationwide risk map developed by the US Forest Service places 14 states in two main areas at risk. The first area includes Washington, Oregon, and California. The second area is in the southern Appalachian Mountains

including Kentucky, Tennessee, Alabama, Georgia, North and South Carolina, Virginia, Maryland, and West Virginia. Portions of coastal Mississippi and Alabama are also considered high risk. The risk assessment is based on host and climate factors, as well as rhododendron nursery locations (4).

IV. RISK ASSESSMENT:

Economic Impact Potential: The potential economic impact of this disease is currently considered "high." This disease has a demonstrable ability to kill healthy mature trees of at least four *Quercus* and *Lithocarpus* species. Given the commercial hardwood value of certain *Quercus*, *Lithocarpus*, and *Castanea* species, economic losses could be very high, especially if related species prove susceptible. Long term reduction in hardwood timber production may result if this disease proves unmanageable. Fuel loading in urban:wildland interfaces could result in high fire prevention costs in areas where these species represent a major component of the forest mix. Hazard tree losses in urban landscapes could also be significant. Impacts to the nursery and landscaping industry may also prove significant. Decreased property value is also possible (5).

Ecological Impact Potential: The potential ecological impact of this disease is currently considered "high." *Quercus* species are often a major component of hardwood forests and play an important ecological role as food and habitat for wildlife. They also provided soil stabilization in watersheds and contribute to ecosystem biodiversity. High losses of trees may result in changes in forest composition, loss of wildlife food and habitat, increased soil erosion, increased fuel loading, and exotic species invasion (5).

V. HOST SPECIES AND SYMPTOMS: There are currently 18 species worldwide that are known to be infected by the fungus that causes SOD, although the symptoms and severity of the disease varies widely by plant species. Seventeen of these species can be found growing in the wild or in cultivation in California (SEE TABLE 1) (6). Infection of a viburnum (*Viburnum* X *bodnantense*) plant in Europe has also

TABLE 1. Known hosts and symptoms of Sudden Oak Death caused by *Phytophthora ramorum* in California[†].

HOST	FAMILY	COMMON NAME	PLANT PART INFECTED	MORTALITY OF ADULT PLANTS	MORTALITY JUVENILE PLANTS
Quercus agrifolia	*Fagaceae*	coast live oak	main stem	yes	no
Quercus kelloggii	*Fagaceae*	Calif. black oak	main stem	yes	no
Q. parvula var. *shrevei*	*Fagaceae*	Shreve's oak	main stem	yes	no
Lithocarpus densiflorus	*Fagaceae*	tanoak	main stem, branches, leaves	yes	yes
Arbutus menziesii	*Ericaceae*	madrone	branches, leaves	probably	yes
Vaccinium ovatum	*Ericaceae*	Calif. huckleberry	main stem, branches, leaves	yes	yes
Arctostaphylos manzanita	*Ericaceae*	manzanita	branches, leaves	unknown	unknown
Rhododendron spp.	*Ericaceae*	rhododendron	branches, leaves	yes	yes
R. macrophyllum	*Ericaceae*	Pacific rhodod.	leaves, branches	yes	yes
Umbellularia californica	*Lauraceae*	California laurel	leaves	no	no
Acer macrophyllum	*Aceraceae*	big leaf maple	leaves	no	no
Heteromeles arbutifolia	*Rosaceae*	toyon	branches, leaves	unknown	unknown
Aesculus californica	*Hippocastanaceae*	Calif. buckeye	branches, leaves	no	no
Frangula californica	*Rhamnaceae*	Calif. buckthorn	leaves	unknown	unknown
Lonicera hispidula	*Caprifoliaceae*	pink honeysuckle	leaves	unknown	unknown
Sequoia spp.	*Taxodiaceae*	redwood	branches, leaves	unknown	unknown
Pseudotsuga menziesii	*Pinaceae*	Douglas fir	branches, leaves	unknown	unknown

[†] - From Garbelotto, et al. 2002. How to recognize symptoms of diseases caused by *Phytophthora ramorum* causal agent of Sudden Oak Death (6). Amended.

been confirmed. The most serious impact, which has caused the death of tens of thousands of trees, has occurred in tanoaks (*Lithocarpus densiflorus*), coast live oaks (*Quercus agrifolia*), and California black oaks (*Quercus kelloggii*). Shreve's oak (*Quercus parvula* var. *shrevei*) is also susceptible. In all cases, this disease appears capable of killing healthy mature trees. Host symptoms typically include a bleeding canker on the stem(s). The common name for this disease is somewhat of a misnomer given cankered trees do not die "suddenly" in many cases, but typically survive 1 to 3 years after infection. Once crown die-back begins, the leaves turn from green to pale yellow to brown within a few weeks. Black or dark reddish ooze sometimes bleeds from the canker, which may be difficult to see as it dries or is washed off by rain. Dead bark tissues surrounded by black zone lines are usually present under affected bark, although these symptoms may be caused by other *Phytophthora* species. In the eastern US, other disorders of oak such as oak wilt (*Ceratocystis fagacearum*), oak decline complex, and red oak borer (*Enaphalodes rufulus*), frequently produce symptoms similar to those caused by SOD. Laboratory tests will be needed to verify the causal agent in most cases. Other disorders with symptoms that may be confused with those of SOD include canker rots, slime flux, leaf scorch, root diseases, freeze damage, and herbicide injury (7). Secondary disorders may colonize SOD-infected trees including sapwood decay fungus (*Hypoxylon thouarsianum*), ambrosia beetles (*Monarthrum* spp.), and bark beetles (*Pseudopityophthorus* spp.), as well as other organisms (8). The pathogen causing SOD also infects *Rhododendron* species, Pacific rhododendron (*Rhododendron macrophyllum*), California huckleberry (*Vaccinium ovatum*), California laurel (*Umbellularia californica*), madrone (*Arbutus menziesii*), bigleaf maple (*Acer macrophyllum*), manzanita (*Arctostaphylos manzanita*), toyon (*Heteromeles arbutifolia*), California buckthorn (*Frangula californica*), pink honeysuckle (*Lonicera hispidula*), and California buckeye (*Aesculus californica*). On these hosts, the disease causes leaf spot and twig dieback (7). Although not as serious a disease on rhododendron, ornamental selections of this species could act as vectors for the spread of SOD to other more sensitive species, and poses serious implications for the nursery and landscape industries. Infection with the SOD pathogen has been recently confirmed in coast redwood (*Sequoia*) and Douglas fir (*Pseudotsuga menziesii*). It is not yet clear to what degree the disease will impact these two extremely important species (9). Tests have shown that northern red oak (*Quercus rubra*) and pin oak (*Quercus palustris*) are also highly susceptible to infection (7).

For graphic examples of SOD and related oak disorder symptoms, reference *How to recognize symptoms of diseases caused by Phytophthora ramorum causal agent of Sudden Oak Death* at *http://nature.berkeley.edu/comtf/pdf/EducationalMaterials/SODDiagnosis2002.pdf* (6).

VI. SAMPLING FOR *PHYTOPHTHORA RAMORUM*: In many cases, laboratory verification of infection with *P. ramorum* will be necessary to distinguish this disease from other disorders. It should be noted that homeowners, landowners, and untrained professionals should **not** sample potentially infected trees because of the risk of spreading the disease. Trained professionals should be contacted when a possible site of infestation has been identified. For instructions on sampling *P. ramorum*, reference *Sudden Oak Death: Diagnosis and Management* at *http://nature.berkeley.edu/comtf/pdf/EducationalMaterials/pestalert5.pdf*. It should be noted that all tools should be treated with 70% ethanol, Lysol®, or 10% household bleach before and after sampling. Flaming of tools is recommended before sampling and when sampling between plants. All tools should also be treated with one of these cleaning agents between pruning cuts on landscape plants and when sampling or pruning different plants (10).

VII. BEST MANAGEMENT PRACTICES: There are currently no known cures or preventatives for SOD. Research is underway studying the efficacy of various fungicides, but results are unavailable at this time. There are preliminary reports of success with fungicide applications on young tanoaks and coast live oaks. Until specific information on the SOD pathogen is available, the best management practices described herein are based largely on the known pathology of other *Phytophthora* species. It should be noted that not all trees in an infested stand become infected, however, genetic-based resistance has not been confirmed. The SOD pathogen produces reproductive structures that in other *Phytophthora* are spread by soil, water, and infected host material, especially under mild, moist conditions. Patterns of SOD spread suggest aerial dispersion as well. *Phytophthora ramorum* has been found in rainwater collected below infected coast live oak stems, and from soil around these trees. The pathogen may be able to survive in a resting stage for substantial intervals of time, and is viable for a

period of time on dead wood (12). Practices that reduce the spread of the SOD pathogen within SOD-infested areas, and between SOD-infested areas and uncontaminated sites, are the primary methods of control at this time. If soil is confirmed as a viable SOD vector, the greatest threat of spread will occur when the soil is damp or wet, and readily adheres to feet, shoes, tires, and construction and tree removal equipment (13).

SOD-Infested Areas

1) Do not transport any confirmed host species out of areas of known SOD infestation. Avoid the movement of any potentially infected material within or out of the zone of infestation.

2) Do not transport plant parts (acorns, leaves, firewood, etc) of any confirmed host species out of areas of known SOD infestation. Avoid the movement of any potentially infected material within or out of the zone of infestation.

3) Do not transport any wood products such as mulch, bark, or firewood taken from confirmed host species out of areas of known SOD infestation. Leave felled trees on site if possible. Chip and scatter branches on site. Do not leave wood near roads where it may be removed from the zone of infestation and used as firewood. Keep wood piles as far away from susceptible hosts as possible. Cover wood with plastic to prevent beetle emergence and weaken *Phytophthora* (SEE DETAILS BELOW). Clean all chain saws, handsaws, axes, mauls, wedges, splitters, and other equipment with a cleaning agent as described in SECTION VI, SAMPLING.

4) Do not transport soil, duff, organic matter, or other substrate out of areas of known SOD infestation.

5) Avoid driving or parking vehicles in SOD-infested areas where they may become contaminated with soil or mud.

6) After visiting a known SOD-infested area, clean the soil from your shoes, sporting equipment, vehicle tires, construction equipment, and pets just before leaving the site.

7) Avoid SOD-infested areas when possible, especially during mild, moist conditions. When hiking in SOD-infested areas, avoid walking in damp or wet soils if possible.

8) In a landscape situation, replace SOD-infected trees and shrubs with non-susceptible species.

9) Promote the health of non-infected trees and shrubs. Prune dead, dying, and hazardous branches. Minimize root damage. Water during drought periods, but avoid over-watering. Mulch with up to 4 inches of clean, coarse bark–not around trunk. Fertilize with nitrogen only when a soil deficiency has been verified. Avoid mechanical injury to the trunk and branches. Inspect trees and shrubs regularly over the growing season for signs of infection and initiate corrective measures as soon as possible.

10) In areas where the western oak bark beetle (*Pseudopityophthorus pubipennis*), oak ambrosia beetle (*Monarthrum scutellare*), and minor oak ambrosia beetle (*Monarthrum detinger*) are know to exist and attack oaks, apply labeled insecticides to control these insects thereby reducing the risk of secondary attack and spreading SOD. Trees infected with the SOD pathogen should be cut into firewood, the branches chipped, the stump ground or completely covered with clear plastic. Cover all wood with clear, 6-mil plastic for 6 months to prevent beetle emergence. Secure the edge of the plastic with rocks and soil to prevent insect escape (11).

11) Inspect ornamental rhododendrons and other SOD hosts used for landscaping for signs of cankers that spread from twig tips to the base of the stem. If infection is suspected, contact your local county agricultural commissioner, State or federal forest health specialist, or University or Extension pathologist. Once infection is verified (which typically requires professional inspection, sampling, and/or laboratory verification), the plant(s) should be properly eradicated.

12) When a dead tree presents an unacceptable hazard, fall the tree along the contour to reduce soil erosion. Chip and scatter branches on-site. Stack wood in a manner that promotes rapid drying. Tarp wood on-site and only under warm, dry conditions.

13) Avoid pruning under mild, wet conditions that favor the spread of the SOD pathogen. Sanitize tools as previously described.

14) Keep the trunks of oak trees and the stems and foliage of other SOD host species as dry as possible (12).

Areas Not Infested With SOD (in reasonable proximity to SOD-infested sites)

1) Promote the health of non-infected trees and shrubs. Prune dead, dying, and hazardous branches. Minimize root damage. Water during drought periods, but avoid over-watering. Mulch with up to 4 inches of clean, coarse bark (not around trunk). Fertilize with nitrogen only when a soil deficiency has been verified. Avoid mechanical injury to the trunk and branches. Inspect trees and shrubs regularly over the growing season for signs of infection and initiate corrective measures as soon as possible.

2) In a landscape situation, plant trees and shrubs that are not susceptible to SOD.

3) Do not import any confirmed host species from areas of known SOD infestation to non-infested sites. Avoid the importation of any potentially infected material into non-infested sites.

4) Do not import plant parts (acorns, leaves, firewood, etc.) of any confirmed host species from areas of known SOD infestation into areas free of SOD infestation. Avoid the importation of any potentially infected material into non-infested sites.

5) Do not import any wood products such as mulch, bark, or firewood taken from confirmed host species from areas of known SOD infestation into non-infested areas. Clean all chain saws, handsaws, axes, mauls, wedges, splitters, and other equipment with a cleaning agent as described in SECTION VI–SAMPLING.

6) Do not import soil, duff, organic matter, or other substrate from areas of known SOD infestation into non-infested sites.

7) Do not plant acorns or other seeds collected from areas of known SOD infestation into non-infested sites. Avoid using confirmed host species in areas likely to support SOD.

8) Inspect ornamental rhododendrons and other SOD hosts used for landscaping for signs of cankers that spread from twig tips to the base of the stem. If infection is suspected, contact your local county agricultural commissioner, State or federal forest health specialist, or University or Extension pathologist. Once infection is verified (which typically requires professional inspection, sampling, and/or laboratory verification), the plant(s) should be properly eradicated (12).

VIII. ADDITIONAL AND UPDATED INFORMATION: For additional and updated information on SOD, visit *http://nature.Berkeley.EDU/comtf/educationmaterials.html, http://www.suddenoakdeath.org,* or conduct an Internet search by Sudden Oak Death.

REFERENCES:

Zandonella, C. 2001. UC researchers announce results that could complicate measures to halt spread of Sudden Oak Death. Campus News, Media Relations, University of California-Berkeley. URL *http://www.berkeley.edu/news/media/releases/2001/01/10_oak.html*

_____2002. OakMapper. Based on information contained in OakMapper database updated September 2002. URL *http://kellylab.berkeley.edu/SODmonitoring/.*

_____2002. Sudden Oak Death making international news. Pacific Coast Nurseryman and Garden Supply Dealer, July 2002, Page 22-23.

Coit, M. 2002. Thirteen states susceptible to Sudden Oak Death: Host plants, other environmental factors being studied for clues. The Press Democrat, September 22, 2002.

Kliejunas, J. 2000. Sudden Oak Death *Phytophthora* sp. Pest Risk Assessment. USDA–Forest Service, Forest Health Protection, State and Private Forestry.
URL *http://camfer.cnr.berkeley.edu/oaks/SODPRA.html.*

Garbelotto, M., D.M. Rizzo, J.M. Davidson, and S.J. Frankel. 2002. How to recognize symptoms of diseases caused by *Phytophthora ramorum* causal agent of Sudden Oak Death. URL *http://nature.berkeley.edu/comtf/pdf/EducationalMaterials/SODDiagnosis2002.pdf.*

O'Brien, J.G., M.E. Mielke, S. Oak, and B. Moltzan. 2002. Sudden Oak Death. USDA–Forest Service, State and Private Forestry, Northeastern Area. Pest Alert, NA-PR-02-02. URL *http://www.na.fs.fed.us/spfo/pubs/pest_al/sodeast/sodeast.htm.*

Frankel, S. 2001. Sudden Oak Death Caused by a New Species, *Phytophthora ramorum*. USDA–Forest Service, Region 5, Forest Health Protection, Pest Alert, NA-PR-06-01. URL *http://www.fs.fed.us/na/morgantown/fhp/palerts/sod/sod.pdf.*

Yang, S. 2002. UC researchers confirm coast redwood and Douglas fir as hosts for Sudden Oak Death pathogen. Campus News, Media Relations, University of California-Berkeley. URL *http://www.berkeley.edu/news/media/releases/2002/09/04_SOD.html.*

Storer, A.J., K.E. Keirnan, N.K. Palkovsky, B.W. Hagen, G.W. Slaughter, N. Maggi Kelly, and P. Svihra. 2001. Sudden Oak Death: Diagnosis and Management. Pest Alert #5, University of California. URL *http://nature.berkeley.edu/comtf/pdf/EducationalMaterials/pestalert5.pdf.*

Palkovsky, N. and P. Svihra. Homeowner's Guide to Sudden Oak Death in Marin County. URL *http://nature.berkeley.edu/comtf/pdf/EducationalMaterials/homeownersguide.pdf.*

_____2001. INTERIM Integrated Pest Management Guidelines for Sudden Oak Death: A WORK-IN-PROGRESS. California Oak Mortality Task Force. URL *http://nature.Berkeley.EDU/comtf/maggis_pages/man_guidelines-adopted032201.html.*

_____2001. Sudden Oak Death Best Management Practices in Zone of Infestation Regulated Areas, California Oak Mortality Task Force Biomass Utilization Committee. URL *http://www.suddenoakdeath.org/*.