TREE NOTES

CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION

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Pitch Canker Disease in California

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Introduction

Pitch canker, an introduced disease of pines caused by the fungus *Fusarium circinatum* Nirenberg O'Donnell (formerly *F. subglutinans* [Wollenweb and Reinking] Nelson, Toussoun and Marasas f. sp. *pini*) was first identified on Monterey pines, *Pinus radiata* D. Don, in California in the summer of 1986. Some of the most severe impacts have been to Monterey pine planted along roadway rights-of-way and in landscape settings: Monterey pine Christmas tree plantations have likewise been impacted in numerous locations. Pitch canker also occurs in California's three native populations of Monterey pine: Point Año Nuevo and the Monterey Peninsula since 1992 and Cambria since 1994.

Outside of California pitch canker also occurs in the southeastern United States from Virginia to Florida and west to Texas, and in Haiti, Mexico, Japan, South Korea, Spain, France, Italy, Chile and South Africa. Genetic analyses of pathogen populations from around the world indicate that the pathogen may have originated in Mexico and that its recent introduction into California came by way of the southeastern United States.

Impacts of the disease include crown dieback and mortality of trees of all sizes. Insects have a significant role in both disease spread and tree mortality.

Tree Species Affected by Pitch Canker

Monterey and bishop pine (*Pinus muricata*) are the tree species most commonly infected in California. However, 18 pine species plus Douglas-fir, either native or planted, are susceptible to this pathogen in greenhouse and field settings (Table 1).

Table 1: Tree species observed to be infected with the pitch canker fungus in nature, and species found to be resistant or susceptible in greenhouse tests.

Species	Common Name	Status	Susceptibility Field [1]	Susceptibility Greenhouse [2]
Pinus attenuata	Knobcone pine	Native	S	S
P. canariensis	Canary Island Pine	Exotic	R	R
P. contorta spp. contorta	Shore Pine	Native	S	S
P. contorta spp. murryana	Lodgepole Pine	Native	N	S
P. coulteri	Coulter Pine	Native	S-	S
P. eldarica	Eldarica Pine	Exotic	N	S
P. halepensis	Aleppo Pine	Exotic	S	S
P. jeffreyi	Jeffrey Pine	Native	N	S
P. lambertiana	Sugar Pine	Native	N	S
P. monphylla	Pinyon Pine	Native	N	S-
P. muricata	Bishop Pine	Native	S	S
P. pinea	Italian Stone Pine	Exotic	R	R
P. ponderosa	Ponderosa Pine	Native	S-	S
P. radiata	Monterey Pine	Native	S	S
P. sabiniana	Gray Pine	Native	S-	S
P. sylvestris	Scotch Pine	Exotic	N	S
P. thunbergii	Japanese Black Pine	Exotic	N	R
P. torreyana	Torrey Pine	Native	S-	S
Pseudotsuga menziesii	Douglas-Fir	Native	S-	S-

1. Field susceptibility is based on observations of natural infections. Species are rated as susceptible (S) if numerous trees are known to be infected and/or some trees have sustained severe damage from pitch canker. Species that have frequently been observed in otherwise infested areas and for which few or no trees are known to have sustained natural infections and none have been heavily damaged by pitch canker are rated as resistant (R); the level of resistance differs within this group. For species rated as S-, one or more infected trees have been observed, but the number of observations is too limited to provide a meaningful estimate of their relative susceptibility. For species rated as N, no infected trees have been observed, but the occurrence of this species in proximity to natural inoculum is too infrequent to conclude that the lack of disease is indicative of resistance.

2. Greenhouse tests of susceptibility were based on the results of artificial inoculations. Species are rated as susceptible (S) if they sustained definite lesions at the site of inoculation, or resistant (R) if there was little or no lesion development. For species rated as S-, most tested individuals were resistant, but a small percentage appeared moderately susceptible

Wilker, K., T.R. Gordon, A.J. Storer, D.L. Wood. 2003. Pitch Canker. Pest Note: UC ANR Publication. Publication Number 74107, http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn74107.html .

Symptoms of Pitch Canker

The signature symptom of pitch canker on pines is a resinous canker that can occur on any woody portion of the tree, including branches, bole, and roots. Resin is copious on the outside of the canker and penetrates deep into the wood, giving it an amber or honey color. Each canker represents a separate infection and multiple infections typically occur on a tree over time. Cankers girdle small diameter stems such as branch tips, tree tops, and the main stem of seedlings and young trees, causing the distal portion of the stem to die. Susceptibility to the disease, and hence symptoms, vary considerably from one tree to the next.

Photo 1: Branch dieback on Monterey Pine.

Typically, the first symptom noticed on mature trees is branch dieback (Photo 1) which results from infections usually within one or two whorls of a branch tip. As the tip dies, foliage distal to the infection initially turns lime green, then progresses to yellow, then reddish brown, and eventually falls from the branch (Photo 2). Red needles are often reflexed.

Photo 2: Progressive symptomatic color change of foliage on girdled stems.

Pine cones abort before or after reaching full size and typically remain closed on infected whorls. The disease intensifies through repeated infections that can lead to extensive dieback in the canopy.

Crown symptoms initially are common in the upper third of the tree canopy. Preferential feeding on suitable branch tips by insect vectors carrying the pitch canker pathogen may explain this observation. As the disease intensifies, dieback spreads throughout the canopy.

Bole cankers are frequently found on trees with severe canopy symptoms. These infections are very conspicuous due to extensive production of resin that can coat lower limbs and several feet of the trunk below the infection (Photo 3). Bole cankers are slightly sunken, up to approximately 8 inches in diameter and usually appear after branch dieback has occurred. In some cases, diseased trees are severely weakened and may suffer top kill due to girdling of the trunk and/or attack by engraver beetles *(Ips* spp). Death of mature trees is often due to bark beetle attack (engraver beetles (*Ips* spp)).

Photo 3: Canker on bole of Monterey Pine.

Infections on Douglas-fir are characterized by tip dieback without copious resin exudation; callous tissue may form at infection sites.

In young Monterey pines, including Christmas trees, resinous cankers often occur at the root crown; the entire tree subsequently wilts and dies. Christmas tree branch infections will occasionally occur in the absence of root crown cankers. Tree death does not follow as rapidly in these cases.

Pitch Canker Fungus Transmission

The progression of pitch canker in California differs somewhat from what has been reported in the southeastern United States (SE US), where disease outbreaks are more sporadic in time and space, and epidemics subside rather quickly as a recovery phase begins. Disease incidence in the SE US has been related to weather events and human activities that cause wounds. Insects appear to be much more important to disease spread and infection in California, where outbreaks are characterized by a high level of disease incidence and progression that can last for many years before subsiding.

The fungus is capable of producing both asexual and sexual spores, but only asexual spores have been observed in nature. Spore deposition studies indicate that sporulation is enhanced during cool-wet conditions, does not occur in cold-wet conditions when average minimum temperatures approach 0ºC, and may occur in warm conditions in the absence of rainfall if high humidity is caused by coastal fog. The spores of *F. circinatum* need an opening in the bark to initiate infection. Such openings can be created by wind, hail, silvicultural practices (pruning, limbing, wounding the tree, etc.), insects, etc. Spore germination and growth both proceed very slowly at 10°C and more rapidly as temperature increases up to 20°C. For this reason, infection rates tend to be lower in winter than during warmer periods. However, higher temperatures will favor infections only if wounds are deep enough to reach moisture within the plant or if ambient humidity is high and/or free moisture is present. Thus, infections mediated by twig beetles (*Pityophthorus* spp.), which create only very shallow wounds on healthy branches, occur at a higher frequency when relative humidity is at or close to 100%. In contrast, where inoculum is delivered to deeper wounds, the effect of ambient humidity on infection frequency is greatly diminished.

Temperature and moisture requirements for infection are consistent with the widespread occurrence of pitch canker in the SE US where rainfall during warm periods is common. Conversely, in California, precipitation occurs primarily during the coolest months of the year and pitch canker is restricted to the Central Coast, where moderate temperatures coincide with high humidity and/or condensation provided by moist marine air. Although the present distribution of pitch canker implies a climatic limitation on the geographic range of the disease, whether or not such limitations remain effective may be contingent on the activity of insect vectors and wounding agents. Whereas twig beetles create shallow wounds on healthy branches, which they find unsuitable for colonization, the cone beetle (*Conophthorus radiatae*) will move the pathogen deeply into host tissue wherein spore germination will not be dependent on ambient moisture. Therefore, if the range of *C. radiatae* expands or other wounding agents with similar feeding/breeding habitats develop an association with *F. circinatum*, pitch canker may become problematic for susceptible trees over a much wider area. In California, this could include coastal areas north of 39°N latitude, where the absence of pitch canker in stands of susceptible species (planted *P. radiata* and native *P. muricata*) presumably reflects the fact that temperatures are relatively cool during periods when moisture is available, which limits opportunities for infection of shallow wounds.

Pitch canker can spread from infected to uninfected trees by wind-driven dispersal of airborne spores. In addition, many species of insects native to California have been shown to carry *F. circinatum*. This includes: twig beetles, cone beetles and engraver beetles all in the family Curculionidae; as well as the deathwatch beetle (*Ernobius punctulatus,* Family Anobiidae) and cylindrical bark beetles (*Lasconotus* spp., Family Zopheridae) (Table 2).

- **Engraver beetles** can cause infections on tree branches and boles by their tunneling activities.
- **Twig beetles** colonize small branches and cone tissue in the upper canopy. Wounds created by exploratory feeding can lead to infection.
- **Monterey pine cone beetles** are more likely to feed in the upper canopy due to the increased availability of cones.
- **The deathwatch beetle** adults may enter the galleries of cone or twig beetles and contribute fungal inoculum (i.e., spores) that leads to infection.
- **Spittlebug**, *Aphrophora Canadensis,* is a wounding agent capable of initiating infections on succulent shoots during late winter and early spring.

Dispersal of insect vectors may spread pitch canker disease to new locations. Most of the beetle species inhabit recently fallen tree material, as well as live trees. Many utilize more than one host tree species and have wide geographic ranges.

Seed coats of Monterey pine can carry the pitch canker fungus and produce infected seedlings. Any seed from a generally infested area can be host to the fungus, including seed from pines with few or no symptoms of disease. Movement of seeds and seedlings of *Pinus* spp. and Douglas-fir is a mechanism by which the pathogen can be introduced into uninfected areas.

Table 2: Bark and cone beetle species from which pitch canker fungus has been isolated.

Monterey pine engraver	*Ips mexicanus*
Four-spined engraver	*Ips plasotgraphus maritimus*
California five-spined ips	*Ips paraconfusus*
Monterey pine cone beetles	*Conophthorus radiatae*
Twig beetles	*Pityophthorus carmeli*, *P. pulchellus tuberculatus*, *P. nitidulus*, *P setosus*
Cylindrical bark beetles	*Lasconotus pertenuis*, *L. nucleatus*

Identification and Similar Pests

There are a number of insects, diseases, and environmental conditions that cause symptoms that may be confused with pitch canker (Table 3). Positive diagnosis requires laboratory isolation and culture of the pitch canker fungus from symptomatic tree tissue.

Table 3: Comparison of pitch canker symptoms with other conditions of Monterey pine.

Key: X: Symptom usually occurs, O: Symptom occasionally occurs.

	Streaming pitch	Yellow to red wilted tip needles	Yellow to red unwilted tip needles	Dead tips, needles fallen	Cone or conelet abortion	Swelling on branch	Lumpy or tubular pitch masses
Pitch canker fungus	X	X	O	X	X		
Western gall rust *Peridermium harknessii*		O	X	O	O	X	
Dwarf Mistletoe *Arceuthobium spp.*			O	O		X	
Diplodia Needle Blight *Deplodia pinea*		X		X			
Monterey pine scale *Toumeyella pinicola*		X		X			
Pitch moth	O						X
Monterey pine tip moth			X	X			
Weevils *Various species*		O	X	X			
Red turpentine beetle *Dendroctonus valens*							X
Ips bark beetles		O	O	O			
Cone beetles					X		O
Twig beetles		O	X	X	O		
Tree pruning or wounding	X					O	
Salt and wind dieback			X	X			
Suppressed branches		O	X	O			

Disease Management

No effective controls for pitch canker, using either chemical or biological agents, are currently available. However, disease progression is quite variable and not all trees will be severely damaged by pitch canker. Even in very susceptible species, such as Monterey pine, it is possible for heavily infected trees to recover. Recovery appears to be due primarily to the occurrence of systemic induced resistance, which has been documented to occur in both native and planted stands of Monterey pine. Consequently, the occurrence of pitch canker is not, by itself, a good reason for removal of a tree. Pruning out of diseased branches (see

below) may be justified if this restores the aesthetic value of tree and thus avoids the cost of removal and replacement.

Available Disease Control Best Management Practices

- **Restricted movement of infested timber out of the Coastal Pitch Canker Zone of Infestation (ZOI)** - Passed in 1997 by the Board of Forestry and Fire Protection, the ZOI encompasses all or parts of 21 counties along the coast of California (Figure 1). Logs from diseased trees harvested on private timberlands cannot be transported out of the ZOI unless mitigations are in place to prevent disease spread.
- **Limit movement of wood with bark attached** - Logs and firewood cut from infected trees should not be moved from the region of origin. To prevent the buildup of destructive beetles, firewood can be seasoned beneath tightly sealed 6 mil UV resistant clear plastic tarp. See CAL FIRE Tree Note #3 for more information on tarping wood and other methods to control insects.
- **Chipping of infested wood** - Chipping will reduce but not necessarily eliminate insects that carry the pathogen. Additionally, chipping will have little impact on pathogen survival. Chipped material is best left on site and spread in a thin layer as ground mulch. Composting chips will eliminate the pathogen if the pathogen is exposed to 50ºC (120ºF) or higher for 10 days.
- **Pruning** to remove infected tips will usually not eliminate the disease. However, if a lightly infected tree is relatively isolated from other diseased trees, removal of infected tips may slow the development of a new disease center. Cut woody material may contain or become infested with insects that carry the pathogen. Burn, cover with a tarp, or chip pruned material. Infected Christmas trees should be treated similarly.
- **Sterilization of pruning tools** with Lysol^{tm} or 10% chlorine bleach [10/90 mixture bleach to water] should be performed before and after pruning operations. A two-minute soak time is required for the bleach solution.
- **Do not collect pine seed** in areas where pitch canker is present. The pitch canker fungus can remain viable even after seeds are surface sterilized. Nurseries should destroy infected seedlings.
- **Plant resistant tree species** - Planting susceptible tree species in areas with pitch canker disease is likely to result in new infections. Such plantings should be avoided in the vicinity of native populations of Monterey, bishop, shore and Torrey pines, as these species have very limited geographic distributions. New ornamental plantings of Monterey are not recommended at this time in California. Resistant Monterey pines have been identified, but generally are not available for planting.
- **High value trees** - Monterey and other pines vary greatly in their susceptibility to pitch canker. Most lightly to moderately susceptible trees recover. It is best to monitor diseased trees before deciding on a course of action. Treating the bole with a pesticide registered to prevent bark beetle attack may help keep lightly to moderately diseased trees alive, especially during periods of drought stress.

Information on registered pesticides can be found at the California Department of Pesticide Regulation.

New occurrences of pitch canker should be reported to the county's agricultural department or the California Department of Forestry and Fire Protection.

Future Implications

The potential for pitch canker to spread is significant considering the susceptibility of most pine species and the efficiency of the associated insect vectors in finding suitable host material. Native Monterey pine and bishop pine stands are at risk, as are landscape plantings of these and numerous other conifers.

The appearance of pitch canker in ornamental plantings of Douglas-fir and ponderosa pine has raised concern that native and commercial stands of these species in nearby coastal forests and the Sierra Nevada may become impacted by this disease. Native and landscape stands of these and other conifers in central coastal California are being monitored for symptoms of pitch canker.

The limited native ranges of Monterey pine, Torrey pine, and bishop pine heighten concern for the effect of pitch canker on these tree species. Monterey pine is the most widely planted timber species in the world, and California's native populations represent a global resource for breeding programs. While the long term impact of pitch canker is uncertain, the potential for the disease to reduce the genetic diversity of these species and the integrity of their native populations continues to be a concern.

Pitch Canker Task Force Website: http://www.ufei.org/pitch_canker/index.html

For information on bark beetles:

- CAL FIRE Tree Note #3: Controlling bark beetles in wood residue and firewood.
- CAL FIRE Tree Note #19: Managing bark beetles in urban and rural trees.

For information on diseases and insects spread by firewood:

- http://www.firewood.ca.gov/

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