

California Pest Rating Proposal for
***Fusarium circinatum* Nirenberg & O'Donnell 1998**
(teleomorph *Gibberella circinata*)
pitch canker of pine

Current Pest Rating: B

Proposed Pest Rating: B

Domain: Eukaryota, Kingdom: Fungi,
Phylum: Ascomycota, Subphylum: Pezizomycotina,
Class: Sordariomycetes, Subclass: Hypocreomycetidae,
Order: Hypocreales, Family: Nectriaceae

Comment Period: 03/21/2022 through 05/05/2022

Initiating Event:

This pathogen has not been through the California pest rating system. The risk to California from *Fusarium circinatum* is described herein and a permanent rating is proposed.

History & Status:

Background: Pitch canker (also called pine pitch canker) is caused by the ascomycete *Fusarium circinatum* Nirenberg & O'Donnell (= *Fusarium subglutinans* (Wollenweb. & Reinking) Nelson, Toussoun, & Marasas f. sp. *pini*). The teleomorph is *Gibberella circinata* Nirenberg & O'Donnell 1998. It was first found in North Carolina in 1946 (Hepting and Roth, 1946). In the U.S. it is known to occur from Florida north to Virginia, and westwards to Texas, affecting a wide range of pines (*Pinus* spp.). These include slash (*P. elliotii*), Virginia (*P. virginiana*), shortleaf (*P. echinata*), loblolly (*P. taeda*), and pitch (*P. rigida*) pines. In these areas, pitch canker occasionally causes epidemics and economic losses, but only in managed stands, such as seed orchards, and it is rarely a problem in native pine stands (Blakeslee and Oak, 1979). Severe disease can be associated with abiotic stress (Lopez-Zamora et al., 2007).

In the mid-1980s, numerous Monterey pines (*P. radiata*) in Santa Cruz County were observed with serious and worsening branch dieback symptoms that did not fit the epidemiology of any previously known disease or disorder. Subsequent investigations by forest pathologists confirmed it was pitch canker, likely introduced from the southeastern United States, although the disease is also present in

Mexico (Britz et al., 2001). Initially, the disease appeared to be limited to landscape plantings, but by 1992, it was found to occur in native populations of *P. radiata* on the Monterey Peninsula (Storer et al., 1994). Pitch canker now occurs sporadically throughout the coastal regions of California, from Santa Barbara to Mendocino with isolated finds as far south as San Diego (Gordon et al., 2001). The most affected tree has been the Monterey pine, but pitch canker has also been found on ponderosa, gray, knobcone, bishop, shore, Italian stone, and Aleppo pines and Douglas-fir (*Pseudotsuga menziesii*). Originally the disease was problematic along highways, in State Parks in planted stands and not in native forests. Mature landscape pines, particularly those in highway plantings, were the most frequently diseased. However, by 1994, pitch canker was confirmed in all three native populations of Monterey pine in California. Bishop pine and knobcone pine, two other closed-cone pine species native to California, have also been damaged by pitch canker (Gordon et al., 2001).

Fungal infection and growth cause girdling lesions on branches, stems, and exposed roots of trees, which in turn cause the trees to excrete large amounts of pitch. Branch dieback and excessive pitch at the lesions attracts engraver beetles (*Ips* sp.), twig beetles (*Pityophthorus* sp.), cone beetles (*Conophthorus radiatae*), and deathwatch beetles (*Ernobius punctulatus*)—all of which can attack the tree and cause additional branch dieback. Multiple infections in one tree can eventually lead to widespread dieback of the crown, and ultimately to tree mortality (McCain et al., 1987).

The disease is mainly found in pines along the coast from San Diego to Mendocino but is concentrated between Santa Barbara to the San Francisco Bay Area. There have been detections in Douglas-fir in a breeding orchard at 1,000 m elevation in El Dorado County (Vogler et al., 2007), and the disease has been found in Christmas tree farms in multiple parts of the state (Correll et al., 1991). *Fusarium circinatum* also colonizes both grasses and dicotyledonous plants without inducing symptoms (Swett and Gordon, 2009; 2012). These herbaceous hosts may facilitate spread of the pathogen between widely separated pine stands and could serve as reservoirs of inoculum in pine seedling nurseries, compromising efforts to manage the disease.

In the late 1990s, it seemed that pitch canker was likely to increase rapidly with potentially irreversible negative impacts on forests. However, disease incidence and severity in Monterey County test plots leveled off and changed very little in the 2000s. Stabilization may be due to induced resistance, where trees that have sustained prior infections become less susceptible over time (Gordon et al., 2011; 2020). Although initially it was recommended that diseased trees be removed quickly to reduce inoculum, it is likely that many landscape trees were removed because of physical hazards, aesthetic damage and loss of horticultural value than would have been lost to severe disease (Swett and Gordon, 2013).

Hosts: Abies alba (silver fir), *Agrostis capillaris* (bent grass), *Arrhenatherum longifolium*, *Briza maxima* (large quaking grass), *Bromus carinatus* (sweet brome), *Calocedrus decurrens* (incense cedar), *Centaurea decipiens*, *Cymbidium* sp., *Ehrharta erecta* (perennial grass), *Holcus lanatus* (fog grass), *Hypochaeris radicata* (flatweed), *Larix decidua* (European larch), *L. kaempferi* (Japanese larch), *Lolium arundinaceum*, *Musa acuminata* (banana), *Pentameris pallida*, *Picea glauca* (white spruce), *Pinus arizonica* (Arizona pine), *P. armandii* (Armand pine), *P. attenuata* (knobcone pine), *P. ayacahuite*

(ayacahuite pine), *P. canariensis* (Canary Island pine), *P. cembroides* (Mexican nut pine), *P. contorta* (lodgepole pine), *P. coulteri* (big cone pine), *P. densiflora* (Japanese pine), *P. discolor*, *P. douglasiana*, *P. durangensis*, *P. echinata* (Arkansas pine), *P. elliotii* (longleaf pitch pine), *P. elliotii* var. *densa* (South Florida slash pine), *P. elliotii* var. *elliotii*, *P. glabra* (spruce pine), *P. greggii*, *P. halepensis* (Jerusalem pine), *P. hartwegii*, *P. kesiya* (Khasi pine), *P. leiophylla* (smooth-leaf pine), *P. luchuensis* (Luchu pine), *P. maximinoi*, *P. montezumae* (rough-bark Mexican pine), *P. muricata* (bishop pine), *P. nigra* (black pine), *P. occidentalis*, *P. palustris* (longleaf pine), *P. patula* (Mexican weeping pine), *P. pinaster* (cluster pine), *P. pinea* (Italian stone pine), *P. ponderosa* (ponderosa pine), *P. pringlei*, *P. pseudostrobus* (smooth bark Mexican pine), *P. radiata* (Monterey pine), *P. rigida* (northern pitch pine), *P. sabiniana* (California foothill pine), *P. strobus* (eastern white pine), *P. sylvestris* (Scotch pine), *P. taeda* (loblolly pine), *P. tecunumanii*, *P. teocote*, *P. thunbergia* (black pine), *P. torreyana* (Torrey pine), *P. virginiana* (Virginia pine), *Pseudotsuga menziesii* (Douglas-fir), *Rubus ulmifolius* (elm-leaf blackberry), *Sonchus oleraceus* (milk thistle), *Teucrium scorodonia* (wood sage), *Zea mays* (maize) (CABI-CPC, 2022; Farr and Rossman, 2022).

Symptoms: Symptoms vary depending on host susceptibility and environmental conditions. Early symptoms of pitch canker on Monterey pine are the accumulation of resin, which may occur at branch whorls or between whorls, followed by chlorotic needles close to the infection site. Eventually all needles distal to the infection become chlorotic and die. The fascicles typically abscise quickly, leaving a bare stem.

The symptom most typically associated with the disease is large resinous cankers on main trunks and lateral branches of susceptible pine species, although other plant parts such as roots, shoots, female flowers and mature cones, seed and seedlings can also be affected. The tips of girdled branches may wilt because of obstructed water flow, leading to bare branch ends. Multiple branch infections can cause extensive dieback in the crown of the tree and may lead to tree mortality.

Each canker or lesion is a separate and distinct infection. Resin (pitch) accumulates on a branch at the site of infection, and under the bark typically appears as honey-colored resin-soaked wood. Flattened or slightly sunken cankers on the main stem of the tree usually appear after the tree already has multiple branch infections. The flow of resin from main stem infections can ooze down the bark several feet below the infection site. Infected trees are often attacked by engraver beetles (*Ips* sp.), which may cause death of additional branches, treetops, or the entire tree (Storer et al., 2002; 2004). Douglas-fir infections often induce no symptoms and infected grasses can also be symptomless.

Fusarium circinatum can also be a cause of seedling mortality. Seedling infections can result from inoculum present on seed, in soil, or the litter layer. Emerging seedlings may die quickly and not develop symptoms that are distinctive enough to be diagnostic. On older seedlings, resin typically accumulates on the stem near the soil line, with honey-colored lesions beneath the bark at the point of infection. Wounding is not a requirement for shoot infection under all circumstances and *F. circinatum* can grow within pine shoot tissue without causing symptoms (Swett et al., 2018).

Transmission: Medium- and short-range dispersal of the pathogen is done with abundant airborne inoculum (Correll et al., 1991). Infections can occur at any time of the year. Insect-mediated infections

are a key element in the pitch canker disease cycle in California. Infections can be initiated by insect-borne inoculum, where the insect is truly a vector, or by inoculum already present on the branch surface, with the insect serving as a wounding agent (Hoover et al., 1996).

Scolytine weevils (Coleoptera: Curculionidae: Scolytinae), including species in the genera *Pityophthorus* and *Ips* and the species *Conophthorus radiatae*, and the beetle *Ernobius punctulatus* (Coleoptera: Ptinidae), have been shown to carry *F. circinatum* and to transmit *F. circinatum* to small branches on Monterey pines. Engraver beetles (*Ips* spp.) are presumed to be responsible for vectoring the pathogen to larger diameter branches and tree trunks, as this is the type of material in which they normally establish galleries. The spittlebug, *Aphrophora canadensis* (Hemiptera: Aphrophoridae), has been shown to act as a wounding agent capable of initiating infections in internodal regions on succulent shoots during the late winter and early spring (Swett and Gordon, 2013).

Fusarium circinatum can survive in and on pine seeds (Barrows-Broadus and Dwinell, 1985). Movement of diseased seed, pine needles or infected nursery stock accounts for some movement over long distances. Movement of unprocessed logs and firewood carries a risk of transmission for both the pathogen and insects (Tkacz et al., 1998). Packaging material made of coniferous wood represents a high risk in the spread of *F. circinatum*. The wood used for packaging is usually inferior quality in terms of physical imperfections and presence of bark. For instance, wood from trees damaged by *F. circinatum* could also be used in wood packaging entering global trade routes. Conifer bark carrying the pathogen may constitute an additional dispersal pathway. Bark is increasingly traded as natural mulch for ornamentals and the pathogen may be present in it (EFSA, 2012).

Damage Potential: *Fusarium circinatum* poses a significant risk to natural pine forests, nurseries, ornamental and landscape plantings, Christmas tree and other commercial pine plantations. Native populations of Monterey pine and other native species are of great ecological value and a defining scenic feature in recreational areas such as Point Lobos State Natural Reserve and San Simeon State Park. The city of Carmel, Pebble Beach and other high-value residential areas reside in Monterey pine forests that are heavily impacted by pitch canker. Trunk infections result in reduced tree growth and poor form, loss of shade and canopy cover, reduced privacy, decreased noise buffering, lower carbon capture, and habitat loss. The native Monterey pine stands serve as the reservoir of genetic material for “radiata pine” plantations planted globally. Monterey pine is a common plantation species in South America, Australia, New Zealand, South Africa, and Spain due to its fast growth rate. In its native range Monterey pine is listed as threatened or endangered by International Union for Conservation of Nature (IUCN) and a California Rare Plant Rank: 1B.1 (rare, threatened, or endangered in CA and elsewhere).

Observations of pitch canker symptoms and mortality on bishop pine (*Pinus muricata*) so far, particularly from Point Reyes National Seashore in Marin County up through Salt Point State Park in northern Sonoma County, indicate that the pathogen's impacts on this pine species are likely to equal or exceed its impacts to Monterey pine. Like Monterey pine, bishop pine is a species of limited natural distribution and is a California Native Plant Society listed species of concern. Additionally, *F. circinatum* has been isolated from shore pine (*Pinus contorta* ssp. *contorta*) in Mendocino County. Whereas previous work by Tom Gordon, UC Davis suggested that the fungus would likely not spread significantly

farther north than northern Sonoma County because of cooler prevailing temperatures, its recent confirmations north of Point Arena, nearly 20 miles north of the Sonoma County line, suggest that it could spread farther than previously thought. Many pine hosts of *F. circinatum*, such as *P. radiata*, *P. muricata*, and *P. attenuata*, are largely limited to California and southern Oregon, but the distribution of *P. contorta* ssp. *contorta* stretches north nearly to Alaska (R. Cobb, pers comm.).

Infections are typically associated with conspicuous resin exudates (pitch bleeding) and particularly in coastal locations, tree mortality. Resin bleeding runs down the trunk and lower branches below the point of the infection. At this point, the breakage of these branches and even the stem can often occur, also wilting and crown dieback may reduce physiological function leading to tree mortality (Wingfield et al., 2008).

Besides cankers, the disease causes mortality of cones and female flowers and reduction in seed quality. On infected branches, cones may abort before reaching full size but may sometimes remain symptomless. Seeds can be colonized by *F. circinatum* internally and externally, but with no visible impact until seed germination. On seed, the pathogen is located mainly on the seed coat. Seeds of taxonomically unrelated species could also act as an inoculum reservoir.

Establishment of *F. circinatum* in nurseries usually is associated with extensive seedling mortality leading to significant economic losses. But there can also be a symptomless phase for seedlings, which can lead to accidental dissemination of infected plants (Wingfield et al., 2008).

Worldwide Distribution: Brazil, Chile, Columbia, Guatemala, Haiti, Japan Korea, Mexico, Portugal, South Africa, Spain, United States (*Alabama, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, Virginia*) (Drenkhan et al., 2020; CABI-CPC, 2022).

Official Control: *Fusarium circinatum* is on the USDA PCIT's harmful organism list for Brazil, Chile, China, Ecuador, European Union, Morocco, New Zealand, Peru, United Kingdom, Uruguay (USDA, 2022). It is on the EPPO's A1 list for Argentina, Brazil, Turkey and United Kingdom, A2 list for Chile, Comite de Sanidad Vegetal del Cono Sur, Jordan, European Plant Protection Organization, European and Mediterranean Plant Protection Organization, European Union, and a quarantine pest for Morocco (EPPO, 2022).

On June 4, 1997, the California State Board of Forestry passed a resolution establishing the Coastal Pitch Canker Zone of Infestation. The Board's action was prompted by ongoing concerns about the spread of pitch canker to new areas and impacts of the disease in areas where it currently exists. This was the first time the Board had established a Zone of Infestation (Zoi) for a tree disease. The Zoi encompasses all or parts of 21 counties on or near the coast from Mendocino County to San Diego County. The Zone includes all infested areas as well as adjacent areas that might reasonably be expected to become infested. The distribution of the disease is discontinuous and thus there are infested as well as uninfested areas within the Zoi. Pitch canker has been an unofficial "B"-rated

disease since 2001. As a result, the local or destination California County Agricultural Commissioner may restrict the movement of known infected host material, and nursery cleanliness standards apply.

California Distribution: Official state records are from Alameda, Los Angeles, Marin, Mendocino, Monterey, Nevada, San Diego, San Francisco, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, and Sonoma counties on *Holcus lanatus*, *Pinus attenuata*, *P. canariensis*, *P. contorta*, *P. halepensis*, *P. muricata*, *P. ponderosa*, *P. radiata*, *P. sabiniana*, *P. torreyana*, *Pseudotsuga menziesii*, and *Schedonorus phoenix* (CDFA PDR database, 2022).

California Interceptions: None

The risk *Fusarium circinatum* would pose to California is evaluated below.

Consequences of Introduction:

- 1) Climate/Host Interaction:** Pitch canker is a serious problem in coastal areas of California because highly susceptible hosts are widely available, the weather is conducive to infection throughout the year, and insect vectors are abundant. Sporulation is enhanced during cool-wet conditions, and may occur in warm conditions in the absence of rainfall if high humidity is caused by coastal fog. The extent to which similar conditions prevail in other parts of the state will largely determine the risk of pitch canker becoming established in those areas.

Evaluate if the pest would have suitable hosts and climate to establish in California.

Score: 2

- Low (1) Not likely to establish in California; or likely to establish in very limited areas.
- **Medium (2) may be able to establish in a larger but limited part of California.**
- High (3) likely to establish a widespread distribution in California.

- 2) Known Pest Host Range:** The host range includes many *Pinus* spp. plus other trees and grasses.

Evaluate the host range of the pest.

Score: 2

- Low (1) has a very limited host range.
- **Medium (2) has a moderate host range.**
- High (3) has a wide host range.

- 3) Pest Reproductive Potential:** *Fusarium circinatum* spreads with airborne spores and can be vectored by insects. It can be seedborne and incite cryptic infections on seedlings, and it can survive in soil. The fungus can produce sexual spores, but only asexual spores have been observed in nature.

Evaluate the natural and artificial dispersal potential of the pest.

Score: 3

- Low (1) does not have high reproductive or dispersal potential.
- Medium (2) has either high reproductive or dispersal potential.
- **High (3) has both high reproduction and dispersal potential.**

4) Economic Impact: Trees can be killed by this disease, but it also is very disfiguring to ornamental plantings. Monterey pine is an important forestry species in locations around the world that maintain quarantines against *F. circinatum*. It is vectored by multiple types of native insects.

Evaluate the economic impact of the pest to California using the criteria below.

Economic Impact: A, B, C, E

- A. The pest could lower crop yield.**
- B. The pest could lower crop value (includes increasing crop production costs).**
- C. The pest could trigger the loss of markets (includes quarantines).**
- D. The pest could negatively change normal cultural practices.
- E. The pest can vector, or is vectored, by another pestiferous organism.**
- F. The organism is injurious or poisonous to agriculturally important animals.
- G. The organism can interfere with the delivery or supply of water for agricultural uses.

Economic Impact Score: 3

- Low (1) causes 0 or 1 of these impacts.
- Medium (2) causes 2 of these impacts.
- **High (3) causes 3 or more of these impacts.**

5) Environmental Impact: Native Monterey pine (*P. radiata*) forests are currently found at three disjunct locations in coastal California, totaling approximately 4,500 ha (Deghi et al., 1995). These trees are significant ecological and recreational resources, but they are also a valuable repository of useful genetic traits for improved varieties of Monterey pine that are widely used by the timber industry internationally. Monterey pine is also an important landscape tree, with tens of millions of planted trees statewide. They are popular for plantings on freeway rights-of-way, where they serve as visual and sound barriers for the adjacent properties (Gordon et al., 2001).

Evaluate the environmental impact of the pest to California using the criteria below

Environmental Impact: A, C, E

- A. The pest could have a significant environmental impact such as lowering biodiversity, disrupting natural communities, or changing ecosystem processes.**
 - B. The pest could directly affect threatened or endangered species.
 - C. The pest could impact threatened or endangered species by disrupting critical habitats.**
 - D. The pest could trigger additional official or private treatment programs.
 - E. The pest significantly impacts cultural practices, home/urban gardening or ornamental plantings.**
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Environmental Impact Score: 3

- Low (1) causes none of the above to occur.
- Medium (2) causes one of the above to occur.
- **High (3) causes two or more of the above to occur.**

Consequences of Introduction to California for *Fusarium circinatum*: High

Add up the total score and include it here. 13

- Low = 5-8 points
- Medium = 9-12 points
- High = 13-15 points**

- 6) **Post Entry Distribution and Survey Information:** Evaluate the known distribution in California. Only official records identified by a taxonomic expert and supported by voucher specimens deposited in natural history collections should be considered. Pest incursions that have been eradicated, are under eradication, or have been delimited with no further detections should not be included.

Pitch canker continues to slowly spread in California and has not fully established in all areas.

Evaluation is 'Medium'.

Score: -2

- Not established (0) Pest never detected in California or known only from incursions.
- Low (-1) Pest has a localized distribution in California or is established in one suitable climate/host area (region).
- Medium (-2) Pest is widespread in California but not fully established in the endangered area, or pest established in two contiguous suitable climate/host areas.**
- High (-3) Pest has fully established in the endangered area, or pest is reported in more than two contiguous or non-contiguous suitable climate/host areas.

- 7) **The final score is the consequences of introduction score minus the post entry distribution and survey information score: (Score)**

Final Score: Score of Consequences of Introduction – Score of Post Entry Distribution and Survey Information = 11

Uncertainty:

There is a higher rate of infection in Monterey pines maintained at 100% relative humidity on the California coast than in trees exposed to a lower relative humidity at more inland locations (Sakamoto et al., 2007). If the frequency and duration of fog events are decreased by climate change, moisture required by the pathogen will be less available, and the risk of infection will be reduced.

Conclusion and Rating Justification:

Due to the ongoing environmental and economic risk factors, the proposed rating for *Fusarium circinatum* is B.

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Responsible Party:

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***Comment Period: xx/xx/2022 through xx/xx/2022**

*NOTE:

You must be registered and logged in to post a comment. If you have registered and have not received the registration confirmation, please contact us at [permits\[@\]cdfa.ca.gov](mailto:permits[@]cdfa.ca.gov).

Comment Format:

- ❖ Comments should refer to the appropriate California Pest Rating Proposal Form subsection(s) being commented on, as shown below.

Example Comment:

Consequences of Introduction: 1. Climate/Host Interaction: [Your comment that relates to “Climate/Host Interaction” here.]

- ❖ Posted comments will not be able to be viewed immediately.
 - ❖ Comments may not be posted if they:
 - Contain inappropriate language which is not germane to the pest rating proposal;
 - Contains defamatory, false, inaccurate, abusive, obscene, pornographic, sexually oriented, threatening, racially offensive, discriminatory or illegal material;
 - Violates agency regulations prohibiting sexual harassment or other forms of discrimination;
 - Violates agency regulations prohibiting workplace violence, including threats.
 - ❖ Comments may be edited prior to posting to ensure they are entirely germane.
 - ❖ Posted comments shall be those which have been approved in content and posted to the website to be viewed, not just submitted.
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Proposed Pest Rating: B
