CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Raffaelea lauricola T.C. Harr., Fraedrich & Aghayeva, 2008

Laurel Wilt

Current Pest Rating: None

Proposed Pest Rating: A

Domain: Eukaryota, Kingdom: Fungi, Phylum: Ascomycota,
Subphylum: Pezizomycotina, Class: Sordariomycetes,
Subclass: Sordariomycetidae, Order: Ophiostomatales,
Family: Ophiostomataceae

Comment Period: 08/26/2021 through 10/10/2021

Initiating Event:

The USDA's Federal Interagency Committee on Invasive Terrestrial Animals and Pathogens (ITAP.gov) Subcommittee on Plant Pathogens has identified the worst plant pathogens that are either in the United States and have potential for further spread or represent a new threat if introduced. *Raffaelea lauricola* is on this list. A pest risk assessment of this fungus is presented here, and an official pest rating for California is proposed.

History & Status:

Background: Since 2003, a wilt disease has been observed causing substantial mortality of redbay (*Persea borbonia*) and other members of the family Lauraceae in the coastal plains of South Carolina, Georgia, and northeastern Florida. In 2008, Fraedrich et al. published that the cause of the extensive tree mortality was from a new disease caused by a previously unknown vascular fungal pathogen they named "laurel wilt". In the same year, Harrington et al. (2008) described the laurel wilt pathogen as a new species of *Raffaelea* by analyses of rDNA sequences. It is a member of the monophyletic group of species with *Raffaelea* and other asexual fungi that are primarily nutritional symbionts of ambrosia beetles. This pathogen produces conidiophores and conidia similar to those of other beetle symbionts that are related to the *Ophiostoma* clade, an infamous group responsible for Dutch elm disease and many other lethal, beetle-transmitted tree diseases around the world.

Beetle entrance holes were noted in the stems and branches of many affected trees by Fraedrich et al. (2008), and several species of ambrosia beetles (Coleoptera: Curculionidae: Scolytinae), were found in symptomatic redbay including *Xyleborus glabratus* Eichhoff. Named the redbay ambrosia beetle, *X. glabratus* is an exotic pest reported only once previously in the United States at Port Wentworth, Georgia in 2002 (Rabaglia et al., 2006). *Xyleborus glabratus* is native to Southeast Asia (e.g., India, Japan, and Taiwan), where it is often associated with plant species in the family Lauraceae. Females can carry the *Raffaelea* sp. in their paired mandibular mycangia, where the fungus reproduces. The budding spores of the *Raffaelea* sp. are thought to ooze from the mycangia, and thus are introduced to the host xylem during beetle tunneling. Fraedrich et al. (2008) hypothesized that the pathogen, inside the exotic redbay ambrosia beetle, was accidentally introduced on solid wood packing material into the Savannah, Georgia area from Asia, and warned that the pathogen and its vector pose a major threat to members of the Lauraceae in the Americas.

Susceptible American natives in the family Lauraceae are all new-encounter or so-called “naïve hosts” lacking in resistance and more susceptible to lethal wilts than Asian Lauraceae species (Ploetz et al. 2013). A single, asexually reproducing clone of *R. lauricola* was found to be responsible for the laurel wilt epidemic in the United States (Hughes 2013). Since it was first noticed in 2003, laurel wilt disease has expanded significantly, moving to new hosts and into new locations, and threatening forest ecosystems across the south east. In addition to widespread mortality of native plants including redbay, swamp bay and sassafras, the first report of infections in avocado (*Persea americana*) came from Jacksonville, Florida in 2007 (Mayfield et al., 2008). Soon after, a southward swath of trees began to die down the eastern flank of the state. Excluding laurel wilt from healthy avocado orchards and managing the disease in affected areas is a major, ongoing challenge (Ploetz et al., 2016).

Umbellularia californica (California bay laurel) is a large evergreen tree species native to southwestern Oregon and the Coastal Ranges and Sierra Nevada of California. In inoculation experiments, Fraedrich (2008) used isolates of *R. lauricola* taken from wilted redbays in South Carolina and Florida to assess the susceptibility of *U. californica*.to laurel wilt. As many as 80% of inoculated seedlings showed sapwood discoloration, wilt, and branch dieback, indicating that this a susceptible host likely to suffer damage from laurel wilt. In 2013, Mayfield et al. showed the redbay ambrosia beetle, *X. glabratus*, could attack and readily produced brood in California bay laurel bolts, suggesting that California bay laurel could be very negatively impacted by this invasive ambrosia beetle and the pathogen in the tree’s native range, which includes large parts of California.

Hosts: The hosts are all members of the family Lauraceae including *Cinnamomum camphora* (camphor laurel), *Laurus nobilis* (sweet bay), *Lindera melissifolia* (pondberry), *Litsea* (may chang), *Litsea aestivalis* (pond spice), *Persea americana* (avocado), *Persea borbonia* (red bay), *Persea humilis* (scrub bay), *Persea palustris* (swamp bay), *Sassafras* sp., *Sassafras albidum* (common sassafras) (Farr and Rossman, 2021).

Symptoms: Ambrosia beetles introduce *R. lauricola* into the xylem of trees. Trees exhibit few external symptoms initially. Small “toothpicks” of compacted sawdust protrude from the bark at the point of attack; however, these “toothpicks” can disintegrate quickly and are not always apparent. Removal of

bark at the point of attack reveals small “shot-holes” from beetle boring with a dark stain extending into the surrounding xylem. The pathogen grows rapidly and trees show a dark black discoloration observable in the stem and branch sapwood within a few weeks of infection. Leaves of deciduous trees turn reddish-brown from lack of water then drop. Leaves on evergreen hosts do not abscise and are retained on the branches. Over time, discoloration becomes extensive through the cross-sectional areas of the xylem. The disease spreads to the crown and redbay trees wilt completely within 12 weeks. Deciduous hosts such as sassafras show a red discoloration on leaves that drop as they die or soon after. Disease progress is most rapid during the spring and summer when trees are actively growing. Avocado symptoms are like redbay symptoms. The terminal leaves wilt and brown to black discoloration appears in the xylem. Symptoms can be more localized in avocado, affecting just branches or portions of the tree (CABI-ISC, 2021).

Transmission: Laurel wilt has spread along the eastern seaboard of the United States due to the flying insect vectors, especially *X. glabratus*, the movement of wood products including firewood infested with the insect and pathogen, and among native and non-native plants that are susceptible to the disease and in which *X. glabratus* reproduces. Rapid spread has occurred where there are (or were) high population densities of redbay and swamp bay. In avocado in Florida, the species of ambrosia beetles that disseminate *R. lauricola* are not as well defined. In avocado orchards, the spread of *R. lauricola* through root grafts between avocado trees is thought to be an important means of transmission because of the rapid rate at which disease foci develop around recently infected trees (Ploetz et al., 2017). Movement of infected nursery stock is a high risk for transmission over long distances (CABI-ISC, 2021).

Damage Potential: Laurel wilt has killed hundreds of millions of redbay trees in the southeastern United States. The disease is significantly damaging other species such as sassafras in natural ecosystems, and avocado in commercial production areas of south Florida. Models suggest that *X. glabratus* can tolerate temperature conditions that occur throughout much of the eastern United States (Koch and Smith, 2008). The disease poses a threat to lauraceous species indigenous to other areas of the Americas as well as Europe and Africa and including the California bay laurel. The United States Forest Service maintains a website that documents the spread of laurel wilt by state, county, and year (https://www.fs.usda.gov/main/r8/forest-grasslandhealth).

Worldwide Distribution: Asia: *China, India, Japan, Myanmar, Taiwan*. North America: *United States* (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Texas) (CABI-ISC, 2021).

Official Control: *Raffaelea lauricola* is on the EPPO’s A1 list for Chile, and the USDA-PCIT’s harmful organism list for Chile, Mexico, and Peru.

California Distribution: None.

California Interceptions: None.

The risk *Raffaelea lauricola* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** It is likely that this pathogen and its vectors can survive everywhere susceptible hosts (i.e. avocado, California bay laurel) are grown

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

   Score: **3**
   - 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 is limited to members of the family Lauraceae.

   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:** *Raffaelea lauricola* is a fungal symbiont with ambrosia beetles that can fly and move with wood products. It reproduces with its vector and can move through root grafts from infected to uninfected trees.

   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:** Laurel wilt has caused serious ecological impacts on forest ecosystems, and the economic impacts on avocado production in the southeastern United States. The same should be expected for California.

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

   Economic Impact: A, B, C, D, 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:** *Cinnamomum camphora*, camphor tree, is very widely planted as a street tree in California and is mapped by Calflora as sporadically adventive or naturalized in coastal California and the Central Valley. The small fruits are dispersed by birds. *Laurus nobilis*, sweetbay, is also planted in California to some degree and is also mapped by Calflora as sporadically adventive or naturalized in south coastal and central California. The only native member of the Lauraceae in California is *Umbellularia californica*, California bay, which is widespread in coastal and foothill forest areas of California. Other members of the family may be occasionally planted as curiosities or ornamentals (R. Price, Primary Botanist, CDFA, pers. comm.; Calflora, 2021).

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

Environmental Impact: A, 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.

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 *Raffaelea lauricola:* High

Add up the total score and include it here. **14**
-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.

Evaluation is 'not established'.

Score: 0

-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* ***= 14***

Uncertainty:

American members of the Lauraceae are usually more susceptible to the disease than are those from the beetle's Asian home range. Natural infection of California bay laurel has not been observed but inoculated plants have developed disease symptoms and fulfilled Koch's postulates. Limited information is available on the extent to which non-lauraceous taxa serve as hosts and reservoirs for *R. lauricola*, *X. glabratus*, and other potential native and exotic ambrosia beetle vectors.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Raffaelea lauricola* is A.

References:

CABI Invasive species compendium. 2021. Laurel Wilt. https://www.cabi.org/isc/datasheet/109424

Calflora Database. *Umbellularia californica*. Accessed 7/1/2021. Berkeley, CA. calflora.org

EPPO Global Database. 2021. https://gd.eppo.int/taxon/ RAFFLA. Accessed 7/1/2021

Farr, D.F., and Rossman, A.Y. Fungal Databases, U.S. National Fungus Collections, ARS, USDA. Retrieved July 1, 2021, from https://nt.ars-grin.gov/fungaldatabases

Fraedrich, S.W., Harrington, T.C., Rabaglia, R.J., Ulyshen, M.D., Mayfield Iii, A.E., Hanula, J.L., Eickwort, J.M. and Miller, D.R., 2008. A fungal symbiont of the redbay ambrosia beetle causes a lethal wilt in redbay and other Lauraceae in the southeastern United States. Plant Disease, 92(2), pp.215-224.

Fraedrich, S.W., 2008. California laurel is susceptible to laurel wilt caused by *Raffaelea lauricola*. Plant Disease, 92(10), pp.1469-1469.

Harrington, T.C., Fraedrich, S. and Aghayeva, D.N., 2008. *Raffaelea lauricola*, a new ambrosia beetle symbiont and pathogen on the Lauracea. Mycotaxon 104: 399-404, 104, pp.399-404.

Hughes, M. A. 2013. The evaluation of natural resistance to laurel wilt disease in redbay (*Persea borbonia*). Ph.D. thesis. Univ. of Florida, Gainesville

Koch, F. H., Smith, W. D., 2008. Spatio-temporal analysis of *Xyleborus glabratus* (Coleoptera: Circulionidae: Scolytinae) invasion in Eastern U.S. forests. Environmental Entomology, 37(2), 442-452.

Mayfield III, A.E., Smith, J.A., Hughes, M. and Dreaden, T.J., 2008. First report of laurel wilt disease caused by a *Raffaelea* sp. on avocado in Florida. Plant Disease, 92(6), pp.976-976.

Mayfield III, A.E., MacKenzie, M., Cannon, P.G., Oak, S.W., Horn, S., Hwang, J. and Kendra, P.E., 2013. Suitability of California bay laurel and other species as hosts for the non‐native redbay ambrosia beetle and granulate ambrosia beetle. Agricultural and Forest Entomology, 15(3), pp.227-235.

Ploetz, R. C., Hulcr, J., Wingfield, M., and de Beer, Z. W. 2013. Ambrosia and bark beetle-associated tree diseases: Black Swan events in tree pathology? Plant Dis. 95:856-872.

Ploetz, R.C., Hughes, M.A., Kendra, P.E., Fraedrich, S.W., Carrillo, D., Stelinski, L.L., Hulcr, J., Mayfield III, A.E., Dreaden, T.J., Crane, J.H. and Evans, E.A., 2016. Recovery plan for laurel wilt of avocado, caused by *Raffaelea lauricola*. Plant Health Progress, 18(2), pp.51-77.

Rabaglia, R. J., Dole, S. A., and Cognato, A. I. 2006. Review of American Xyleborina (Coleoptera: Curculionidae: Scolytinae) occurring north of Mexico, with an illustrated key. Ann. Entomol. Soc. Am. 99:1034-1056.

USDA Phytosanitary Certificate Issuance and Tracking System, Phytosanitary Export Database (PExD) Harmful Organisms Database Report. *Raffaelea lauricola*. Accessed 7/1/2021

Responsible Party:

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***Comment Period: 08/26/2021 through 10/10/2021**

***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.

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.

Proposed Pest Rating: A
