CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Ophiostoma ulmi (Buisman) Nannf. 1934
≡*Ceratocystis ulmi* (Buisman) C. Moreau 1952
Dutch elm disease

Current Pest Rating: C

Proposed Pest Rating: C

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

Comment Period: 04/03/2023 through 05/18/2023

Initiating Event:

This pathogen has not been through the pest rating process. The risk to California from *Ophiostoma ulmi* is described herein and a permanent rating is proposed.

History & Status:

Background:

Dutch elm disease is a fungal disease that has had a devastating impact on elm trees throughout the world. The disease is caused by two species of fungi, *Ophiostoma ulmi* and *Ophiostoma novo-ulmi*, which are spread by elm bark beetles. Once a tree is infected, it can rapidly decline and die within a few years. Elm trees (*Ulmus* spp.) are confined mainly to the temperate regions of the Northern Hemisphere. China and Japan have a total of about 25 elm species, while Eurasia, North America, and the Himalayas each have about five or six species. There are no species native to California, but they are widely planted in urban areas and are an important street tree, reaching heights of 80', grown for shade and fall colors.

The disease first appeared in the Netherlands in the early 20th century, hence the name Dutch elm disease. It is believed to have been brought to the Netherlands on logs imported from North America, although the origin is suspected to be in Asia. Its remarkable spread throughout Europe, western and central Asia, and especially North America is often used as an example of the dangers of accidental

introductions of invasive and exotic pathogens. Its close association with bark beetles from the genera *Scolytus* and *Hylurgopinus* made spread over large areas possible with an integration into a fully functioning host-vector-pathogen system. People have further helped to quicken the spread by transport of infested timber and firewood over large distances. During its most active time (ca 1910-1940), *O. ulmi* killed at least 10% of the European elms and caused even higher losses in the more susceptible American elm species (Brasier, 2001). However, *O. ulmi* has today lost some of its importance due to competition with a sister taxon, *O. novo-ulmi*, which shows higher virulence, higher bark colonization ability and a higher growth rate at lower temperatures. In the United States, *O. ulmi* was first found in Ohio and some states on the east coast in the early 1930s; by 1973, it had spread westward to the Pacific coast states. It is estimated that in the United States alone, over 100 million elm trees have been lost to the disease in a century (CABI, 2023).

Dutch elm disease has a significant impact on the environment and the economy. The first California detection was made in 1975 in Sonoma County. Since then, Dutch elm disease has spread throughout the San Francisco Bay area, east to Placer County and south as far Santa Cruz County. In 1990, the disease was found in Sacramento, and tree deaths increased exponentially here in the years since. Elm trees are important shade trees and are also valued for their aesthetic qualities. The loss of these trees has a major impact on the environment, including the loss of habitat for wildlife and the reduction of air quality. The economic impact of the disease is also significant, as elm trees are often planted as street trees and their removal can be costly and decrease property values. While efforts to control the disease have had limited success, ongoing research into disease-resistant varieties of elms provides hope for the future. It is important to take steps to prevent the spread of the disease and to report any suspected cases to help limit its impact.

Hosts: Ulmus alata (winged elm), *Ulmus americana* (American elm), *Ulmus davidiana* (Japanese elm), *Ulmus glabra* (mountain elm), *Ulmus laciniata* (Manchurian elm), *Ulmus* laevis (Russian white elm), *Ulmus minor* (European field elm), *Ulmus procera* (English elm), *Ulmus rubra* (slippery elm), *Ulmus serotina* (red elm), *Ulmus thomasii* (rock elm) and *Zelkova carpinifolia* (caucasian elm) (Masuya et al., 2010).

Symptoms: Dutch elm disease is a vascular wilt disease. The earliest external symptoms of infection are often yellowing and wilting (flagging) of leaves on individual branches. These leaves often turn brown and curl up as the branches die, and eventually the leaves may drop off. Although initially only a part of the tree crown may be affected, symptoms may progress rapidly throughout the crown.

The extent of symptoms in the crown is correlated with the extent of vascular invasion of the fungus. In the early stages of infection, the mycelium invades primarily the vessels and only occasionally the tracheids, fibers, and the surrounding parenchyma cells. General invasion of tissue begins at the terminal or extensive dieback phase of the disease. Gums and tyloses are produced in the larger vessels, and sometimes isolated areas of the sapwood are blocked by a combination of gums, tyloses, and fungal growth. Infection also induces browning of the water-conducting vessels. Symptoms can be confused with those from other pathogens that cause vascular browning, including *Verticillium*. (D'Arcy, 2000; Agrios, 2005).

Infected twigs and branches wilt and die. Infections that take place in the spring or early summer allow spores to invade the long vessels of the elm springwood, through which they can be carried rapidly to all parts of the tree. If extensive vascular invasion occurs, the tree may die within a few weeks. During later infections, vascular invasion is limited to the outer, shorter vessels of the summerwood in which they move only for short distances. As a result, late infections may produce only localized infections and seldom cause serious immediate damage to the tree. The fungus overwinters in the bark of dying or dead elm trees and logs as mycelium and as spore-bearing coremia.

Transmission: This disease is not seed borne. *Ophiostoma ulmi* spreads to new hosts via root grafts, which frequently occur between neighboring trees. Large elms growing within 7 meters (20 feet) of each other have almost 100% chance of becoming infected through root grafts. The likelihood of spread is lower when the elms are at least 13 meters (40 feet) apart. The inoculum goes directly into the stem and is carried upwards with the sapstream, affecting the whole tree simultaneously (D'Arcy, 2000). Susceptible elms may be killed soon after infection via root grafts (Stipes, 2000).

Vector transmission is the most important means of dispersal for *O. ulmi*. The fungus in North America is associated with these bark beetles: *Scolytus multistriatus* (introduced from Europe, C-rated in California) and *Hylurgopinus rufipes* (American elm bark beetle, not known to be in California). Elm bark beetles prefer to lay their eggs in the intersurface between bark and wood of trees weakened or dying from drought or disease. If the tree was already infected with the fungus, the fungus produces mycelium and sticky, *Graphium*-type spores in the beetle tunnels. When the adult beetles emerge, they carry thousands of fungus spores on their bodies.

Scolytus beetles usually feed on twig crotches and prefer vigorously growing young twigs at the crown periphery (Stipes and Campana, 1981). As the beetles burrow into the bark and wood, spores are deposited in the wounded tissues of the tree, germinate, and grow rapidly into the injured bark and the wood. When the fungus reaches the large xylem vessels of the spring wood, it produces Sporothrix-type spores, which are carried up by the sap stream. These spores reproduce by yeast-like budding, germinate, and start new infections.

The bark beetles breed in the inner bark of cut, diseased or otherwise weakened elm stems. The dispersing adult beetles fly to healthy elms, where they feed, or to declining elms where they breed. There are usually two to three generations of beetles per year. In each generation, the young adult beetle goes from dead or weakened elm trees to living, vigorous ones on which it feeds and then returns to the dead or weakened trees to lay its eggs (Haugen, 1998). Once an insect becomes contaminated with fungus spores, it may carry them to either healthy or diseased wood, in both of which the fungus grows and multiplies and may contaminate all the offspring of the insect as well as any other insects that visit the infected wood (D'Arcy, 2000; Agrios, 2005).

Worldwide Distribution: Asia: *India, Iran, Japan, Tajikistan*. Europe: *Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Spain, Sweden, Switzerland, Türkiye, Ukraine, United Kingdom*. North America: *Canada, Mexico, United States of America* (Alabama, Arkansas, California, Colorado, Connecticut, Delaware, Georgia, Idaho,

Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming). Oceania: *New Zealand* (EPPO, 2023; Farr and Rossman, 2023).

Official Control: *Ophiostoma ulmi* is on the EPPO's A1 list for Chile, A2 list for the Asia and Pacific Plant Protection Commission (APPPC), and a quarantine pest in Canada and China (EPPO, 2023). It is on the USDA PCIT's harmful organisms list for Canada, Chile, China, Japan, Namibia, South Africa, and Taiwan (USDA PCIT, 2023).

California Distribution: Alameda, Contra Costa, Marin, Napa, Placer, Sacramento, San Mateo, Santa Clara, Santa Cruz, Sonoma, and Yolo counties (French, 1989; CDFA PDR database, 2023).

California Interceptions: none

The risk *Ophiostoma ulmi* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** This pathogen is likely to be found in all climatic zones where elms can grow. The climatic range of the beetle vectors may be more restricted.

   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 natural host range is restricted to elms, *Ulmus* spp., and *Zelkova carpinifolia*.

   Evaluate the host range of the pest.

   Score: 1
   - 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:** This pathogen spreads through root graphs and natural spread in the absence of vectors is slow. However, having multiple flying vectors that spread the pathogen through feeding has allowed rapid spread across large areas.

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:** Dutch elm disease is very destructive. It affects all elm species but most severely the American elm. The disease may kill branches and entire trees within a few weeks or a few years from the time of infection. Hundreds of thousands of elm trees in towns across the country die from Dutch elm disease every year. The cost of cutting down diseased and dead elm trees amounts to many millions of dollars per year, plus the loss of the value of mature trees.

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

Economic Impact: A, 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:** In the absence of effective disease management, Dutch elm disease increases exponentially until an affected elm population is greatly depleted. Seedlings and many saplings escape and live long enough to reproduce but large, mature trees are quickly lost.

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: 2
- 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 *Ophiostoma ulmi:* Medium

Add up the total score and include it here. **11**
-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.

Ophiostoma ulmi has been in California for nearly 50 years. It has spread throughout the San Francisco Bay area, Sonoma, Napa, and Sacramento valleys. It is not in Southern California, possibly because the elms planted tend to be more resistant species, such as the Siberian elm.

Evaluation is 'High'.

Score: -3
-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* ***= 8***

Uncertainty:

To date, all official detections have been of *O. ulmi*. It is possible that the sister taxon *O. novo-ulmi* is here but has not been diagnosed, as it causes the same symptoms on elms.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Ophiostoma ulmi* is C.

References:

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French, A. M. 1989. California plant disease host index. CA Division of Plant Industry. 2nd Ed. 394 pg

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Responsible Party:

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***Comment Period: 04/03/2023 through 05/18/2023**

***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: C
