California Pest Rating Proposal for

Candidatus Phytoplasma mali Seemüller & Schneider, 2004

Apple proliferation disease

Current Pest Rating: none

Proposed Pest Rating: A

Kingdom: Bacteria, Phylum: Tenericutes,
Class: Mollicutes, Order: Acholeplasmatales,
Family: Acholeplasmataceae

Comment Period: 07/16/2025 through 08/30/2025

Initiating Event:

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

History & Status:

Background:

Apple proliferation disease was first observed in Italy in the early 20th century, with the earliest reports dating back to the 1930s. At that time, growers in northern Italy noticed apple trees with abnormal shoot growth, witches' brooms, small and poor-quality fruit, and general tree decline. Initially, the cause was unknown, and the disease was often confused with other disorders or nutrient deficiencies. For decades, the precise cause remained a mystery. In the 1950s–1970s, researchers recognized that apple proliferation was not due to fungi, bacteria that could be cultured, or viruses. It wasn't until the development of improved microscopy and molecular techniques that scientists identified the involvement of phytoplasmas belonging to the class Mollicutes.

Formerly referred to as Mycoplasma-like organisms, phytoplasmas are phloem-limited prokaryotes, lacking a cell wall. They are mainly transmitted by leafhoppers, though they can also be moved with plant propagative materials. A broad diversity of strains have been associated with disease symptoms in hundreds of plant species (Lee et al., 2000). Many cause yellowing symptoms by clogging phloem tissue sieve tubes and interfering with the transportation of photosynthate out of the leaves. They can also produce biologically active toxic substances, causing death of the leaves, inflorescences, and vegetative buds of their hosts. Brooms can be a symptom of phytoplasma infection; they are a dense mass of shoots growing from a single point, with the resulting structure resembling a broom or a bird's nest. Species descriptions of bacteria belonging to the class Mollicutes typically require an accompanying culture of the organism. However, because phytoplasmas are very difficult to isolate in culture and maintain in vitro, lineages within this group are generally referred to as '*Candidatus* Phytoplasma species' (Davis and Sinclair, 1998; Firrao et al., 2004). Molecular analyses have provided information about the diversity and genetic interrelationships of phytoplasmas. A classification scheme based on actual and virtual RFLP analyses of the 16S rRNA gene sequence has allowed the identification of 36 phytoplasma groups and more than 100 subgroups. To date, nearly 50 species of the provisional genus *Ca*. Phytoplasma have been formally described (Miyazaki et al., 2018).

Studies confirmed that the specific agent of apple proliferation disease (APD) is *Ca.* Phytoplasma mali, part of the 16SrX (apple proliferation) group. This discovery provided a clearer understanding of the disease's biology and helped differentiate it from other phytoplasma-associated disorders. APD remains confined mainly to Europe, though isolated detections have arisen elsewhere. In some regions, APD has been present for decades but only causes sporadic or mild symptoms, while in others, severe outbreaks have occurred, especially under favorable conditions for insect vectors. In the United States, *Ca.* Phytoplasma mali is considered a quarantine pest, and stringent import restrictions are in place to prevent its introduction.

Given the economic impact, many European countries enacted quarantine and certification programs to reduce the movement of infected plant material. Integrated pest management (IPM) strategies focusing on vector control, removal of infected trees, and use of certified disease-free planting stock became common. Despite these efforts, the disease remains difficult to eradicate due to the widespread presence of vectors and latent infections.

Hosts: Apples are the main host. Cultivars vary in susceptibility, but resistance has not been identified. Other natural and experimental hosts include:

Carpinus betulus (European hornbeam), *Convolvulus arvensis* (field bindweed), *Corylus avellana* (common hazel), *Crataegus monogyna* (common hawthorn), *Dahlia hybrids* (dahlia), *Forsythia suspensa* (weeping forsythia), *Lilium hybrids* (lily), *Malus baccata* (Siberian crabapple), *M. domestica* (apple), *M. floribunda* (Japanese flowering crabapple), *M. fusca* (Oregon crabapple), *M. halliana* (Hall's crabapple), *Ma. hupehensis* (tea crabapple), *M. kansuensis* (Kansu crabapple), *M. prunifolia* (plumleaf crabapple), *M. sargentii* (Sargent's crabapple), *M. spectabilis* (Chinese flowering crabapple), *M. sylvestris* (European wild apple), *M. toringoides* (cut-leaf crabapple), *Malus x adstringens* (hybrid crabapple), *Malus x atrosanguinea* (hybrid crabapple), *Malus x magdeburgensis* (hybrid crabapple), *Malus x micromalus* (hybrid crabapple), *Malus x moerlandsii* (hybrid crabapple), *Malus x purpurea* (purple crabapple), *Malus x scheideckeri* (hybrid crabapple), *Malus x soulardii* (Soulard crabapple), *Malus x zumi* (Zumi crabapple), *Prunus armeniaca* (apricot), *P. avium* (sweet cherry), *P. domestica* (European plum), *P. persica* (peach), *P. salicina* (Japanese plum), *Punica granatum* (pomegranate), *Pyrus communis* (European pear), *P. pyrifolia* (Asian pear), *Quercus robur* (English oak), *Q. rubra* (northern red oak), *Ribes* sp. (currant/gooseberry), *Solanum lycopersicum* (tomato), *Spiraea x vanhouttei* (Vanhoutte spirea), *Viburnum lantana* (wayfaring tree), and *Vitis vinifera* (grapevine) (EPPO database, 2025).

Symptoms: Affected apple trees exhibit reduced vigor, with visibly thinner shoots. The bark often develops a longitudinally fluted appearance and may turn reddish-brown. Necrotic lesions can form on the bark, and some branches may die. In severe cases, the entire tree may decline and die. However, trees with mild infections sometimes recover after the initial decline phase, typically lasting 2–3 years, especially if managed with proper fertilization. Once recovered, these trees may resume producing normal fruit, although latent infection may persist. During the remission period, the pathogen remains detectable in the roots (Seemüller et al., 2004).

One of the earliest and most characteristic symptoms is abnormal bud development. Terminal buds often exhibit delayed dormancy and may continue to grow late into autumn. These buds sometimes develop rosettes of small, densely clustered leaves, which frequently become infected with powdery mildew. Another important diagnostic symptom is the premature development of axillary buds within the first 2–3 years of infection. These buds give rise to secondary shoots that cluster near the apex of the main shoot, forming witches' brooms. In contrast, healthy trees typically produce lateral shoots near the base of the current season's growth.

In infected trees, the angle between secondary shoots and the main axis is narrower than normal. Witches' brooms can appear progressively on different parts of the tree, or they may develop simultaneously across the canopy. It is uncommon for witches' brooms to reappear repeatedly on the same branch. Leaves emerge earlier in the season than normal and tend to be smaller, with irregular and finely serrated margins. Chlorosis (yellowing) and reddening of the leaves frequently occur, particularly in trees growing on calcareous soils. Early leaf drops are also common.

The leaf discoloration (chlorosis and reddening) is not diagnostic of apple proliferation disease and can be caused by other biotic or abiotic stress factors. Stipules become abnormally elongated, sometimes with up to four stipules per leaf instead of the usual two. Petioles are often shortened, contributing to the distorted leaf appearance. Flowering is often delayed, sometimes occurring as late as late summer or autumn. Despite the delay, most flowers appear morphologically normal. However, in some cultivars, notably Malus domestica cv. Cox's Orange Pippin, malformed flowers, referred to as "phylloid flowers", have been observed. In these cases, stamens may be transformed into petal-like structures, petals into leaf-like structures, and the calyx lobes may be enlarged and toothed.

Fruit size is significantly reduced, sometimes to only 25% of the weight of fruit from healthy trees. Fruit quality deteriorates, with reduced sugar content, lower acidity, and poor flavor development. Fruit from infected trees has longer, thinner peduncles, a flattened fruit shape due to broader and shallower calyx and peduncular cavities, and smaller seeds and seed cavities (Janik et al. 2020; EPPO datasheet, 2025; Seemüller et al., 2004; 2011).

Transmission: The psyllids *Cacopsylla picta* (syn. *C. costalis*) and *Cacopsylla melanoneura* (Hemiptera: Psyllidae), and the leafhopper *Fieberiella florii* (Hemiptera: Cicadellidae) have been shown to be *Ca*. P.

mali vectors (Janik et al., 2020). The Cacopsylla spp. are not known to be in California, but *Fieberiella florii*, the privet leafhopper, is present in the state and is C-rated. *Fieberiella florii* is an important vector of western X-disease caused by *Ca.* Phytoplasma pruni (Gold and Silvester, 1982).

The leafhoppers transmit the phytoplasma in a persistent-propagative manner, which means that the pathogen can multiply in the insects and that they remain inoculative for life (Weintraub and Beanland, 2006). *Cacopsylla picta* vertically transmits *Ca.* P. mali from infected mothers to their offspring (transovarial transmission) (Mittelberger et al., 2017).

Natural movement of insect vectors plays a significant role in spreading the phytoplasma over short distances, between trees within the same orchard or between adjacent orchards. Transmission by root fusion may occur. There is no seed or pollen transmission (Seidl and Komarkova, 1974). Movement of infected planting material has also contributed to disease spread.

Damage Potential: Apple proliferation disease is recognized as one of the most economically significant phytoplasma diseases affecting apple production, particularly in Europe (EPPO datasheet, 2025; CABI, 2025). The disease is most severe in the northern regions of southern Europe, where climatic conditions, especially moderate temperatures, are highly favorable for symptom development (Seemüller et al., 1998a; Jarausch et al., 2019). In areas with cooler or significantly warmer climates, AP occurs less frequently or remains of limited economic concern (Seemüller et al., 1998a).

During the acute phase of APD, often referred to as the "shock phase," crop losses can reach as high as 80% (Smith et al., 1988; Németh, 1986). Even after the shock symptoms subside, a substantial proportion of fruit remains undersized, contributing to ongoing economic losses. In severe cases, prolonged infection can lead to the premature decline or death of affected trees (Seemüller, 1990; Jarausch et al., 2019).

Nearly all commercial apple cultivars are considered susceptible to APD (Seemüller et al., 1998b), with the disease responsible for substantial yield and quality losses. Reported impacts include reductions in fruit size by up to 50%, fruit weight losses of 63–74%, and significant declines in fruit quality due to lowered sugar and acid content (EPPO datasheet, 2025; CABI, 2025; Seemüller et al., 1998b). Infected trees also exhibit diminished vigor and increased vulnerability to secondary pathogens, including powdery mildew (Maszkiewicz et al., 1980) and silver leaf disease (Németh, 1986).

Worldwide Distribution: Americas: *Canada*. Asia: *Syrian Arab Republic*. Africa: *Tunisia*. Europe: *Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, Finland, France, Germany, Greece, Hungary, Italy, Lithuania, Moldova, Republic of, Netherlands, Norway, Poland, Romania, Russian Federation (the), Serbia, Slovakia, Slovenia, Spain, Switzerland, Türkiye,* and *Ukraine* (EPPO, 2025).

Official Control*: Ca.* Phytoplasma mali is on the EPPO's A1 list for Argentina, Bahrain, Brazil, Chile, Comité de Sanidad Vegetal del Cono Sur (COSAVE), Egypt, Georgia, Islamic Republic of Iran, Jordan, Kazakhstan, Paraguay, Uruguay, and the United Kingdom. It is on the EPPO's A2 list for Eurasian Economic Union (EAEU), European and Mediterranean Plant Protection Organization (EPPO), Serbia, and Türkiye, a quarantine pest in Canada, China, Israel, Korea, Mexico, Moldova, Morocco, Norway, Tunisia, and the United States of America, and is a regulated non-quarantine pest in Switzerland (EPPO, 2025). It is on the USDA PCIT's harmful organisms list for Antarctica, Argentina, Brazil, Chile, Colombia, Ecuador, Eurasian Customs Union, Georgia, Japan, Mexico, Morocco, the Republic of North Macedonia, Serbia, and Uruguay (USDA-PCIT, 2025).

California Distribution: none.

California Interceptions: none.

The risk that *Candidatus* Phytoplasma mali would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** This pathogen is likely to be found wherever its hosts are grown. The spread of the pathogen relies on vectors. In Europe, it is found in areas with climates similar to those found in California apple-growing 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 be established in a larger but limited part of California.
   - High (3) likely to establish a widespread distribution in California.

2) **Known Pest Host Range:** This is a major disease of apples, and hosts in other families have been recorded.

   Evaluate the host range of the pest.

   Score: 3

   - 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 is an obligate, fastidious pathogen that lives only within its hosts and its vectors. Long-distance spread is with the movement of infected nursery stock.

   Evaluate the natural and artificial dispersal potential of the pest.

   Score: 2

   - 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:** This is a serious and destructive disease of apples, where it is established.

Evaluate the economic impact of the pest on 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 (including increasing crop production costs).
C. The pest could trigger the loss of markets (including 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:** This disease could impact home and urban gardening and ornamental plantings.

Evaluate the environmental impact of the pest on California using the criteria below.

Environmental Impact: 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 *Ca.* Phytoplasma mali*:* Medium

Add up the total score and include it here. **12**

-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 the 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* ***= 12***

Uncertainty:

none

Conclusion and Rating Justification:

Based on the evidence provided above, the proposed rating for ***Ca.*** **Phytoplasma mali is A.**

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*Comment Period: 07/16/2025 through 08/30/2025

*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