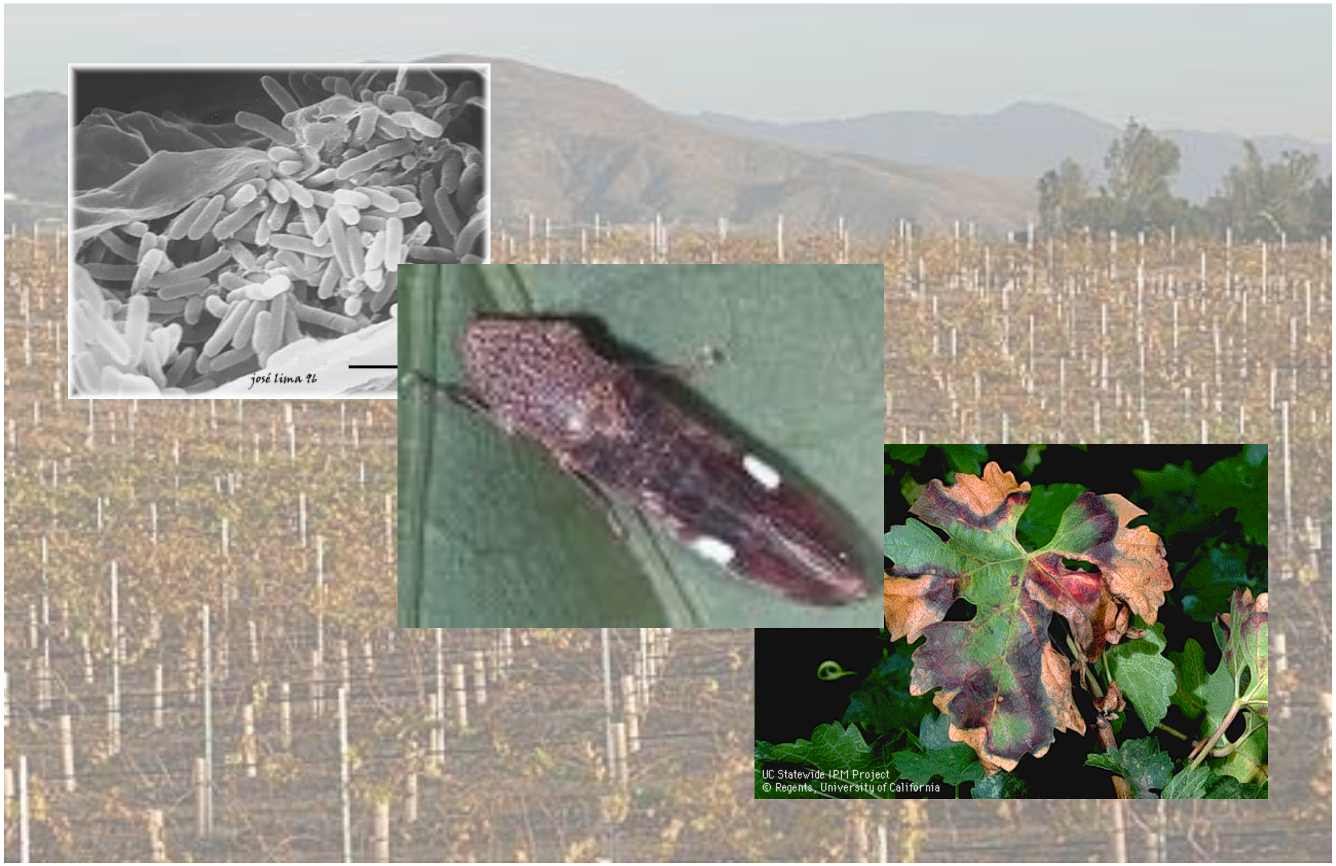
Xylella fastidiosa diseases: tales of a generalist plant pathogen



Matt Daugherty, Department of Entomology,
UC Riverside (mattd@ucr.edu)

Xylella fastidiosa: the early years

"Anaheim vine disease"

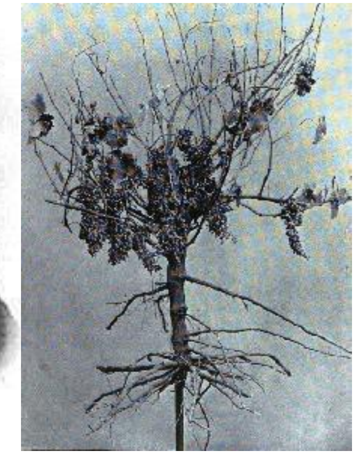
- 1882
- 30,000 - 40,000 acres lost
- 50 wineries closed

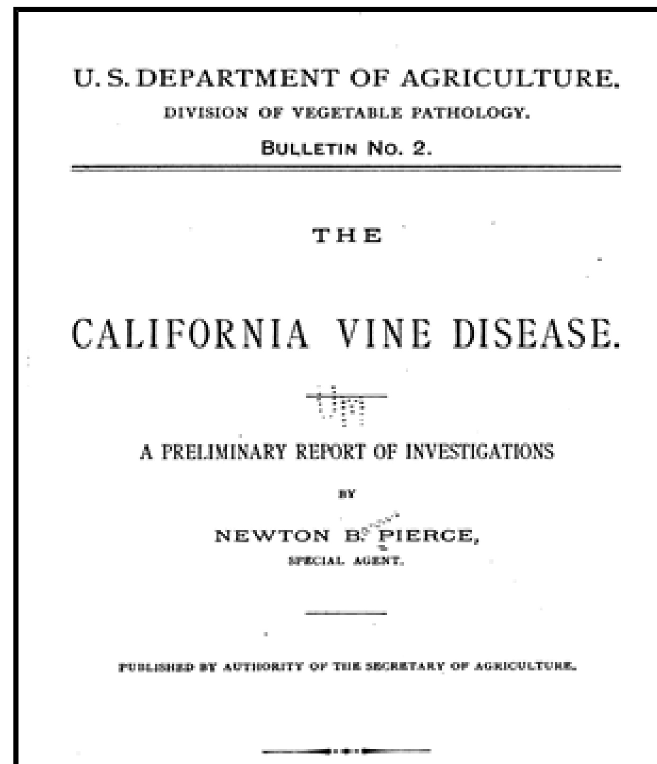
Pierce investigated viticulture, climate, epidemiology

Vector and pathogen not known

- thought to be a virus

Isolated, identified as bacterium in 1978





U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF VEGETABLE PATHOLOGY.

BULLETIN No. 2.

THE

CALIFORNIA VINE DISEASE.

A PRELIMINARY REPORT OF INVESTIGATIONS

BY

NEWTON B. PIERCE,

SPECIAL AGENT.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

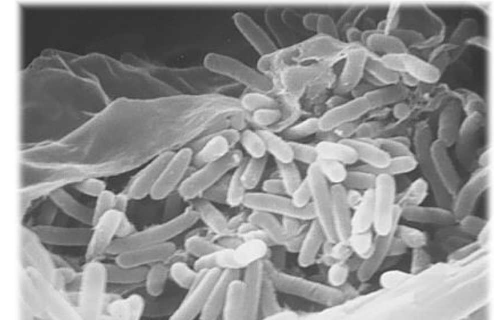
Pierce's disease of grapevines

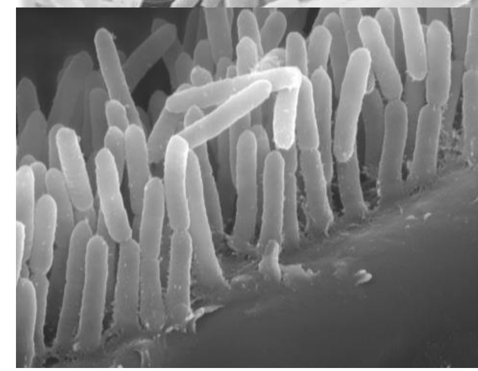
Xylella fastidiosa

Xylem-limited bacterium

Endemic to the Americas…and spreading

Infects over 100 species of native, ornamental, & weedy plants





Xylella diseases

Progressive leaf scorch or stunting symptoms, plant death

Lots of variability in susceptibility among hosts, plant cultivars

Grapevines among the most susceptible hosts

Xylella fastidiosa is a generalist plant pathogen

100s of plant species from dozens of families

maple, box elder, buckeye, ragweed, coyote brush, wild oat, Brassica, Datura, brome, sedges, citrus, coffee, olive, bindweed, Erodium, ginko….

Host Plants and Other Plants Affected

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Plant name	Family	Context
Acer (maples)	Aceraceae	Main
Acer macrophyllum (broadleaf maple)	Aceraceae	Other
Acer negundo (box elder)	Aceraceae	Other
Acer platanoides (Norway maple)	Aceraceae	Other
Acer rubrum (red maple)	Aceraceae	Wild host
Acer saccharum (sugar maple)	Aceraceae	Main
Aesculus (buckeye)	Hippocastanaceae	Other

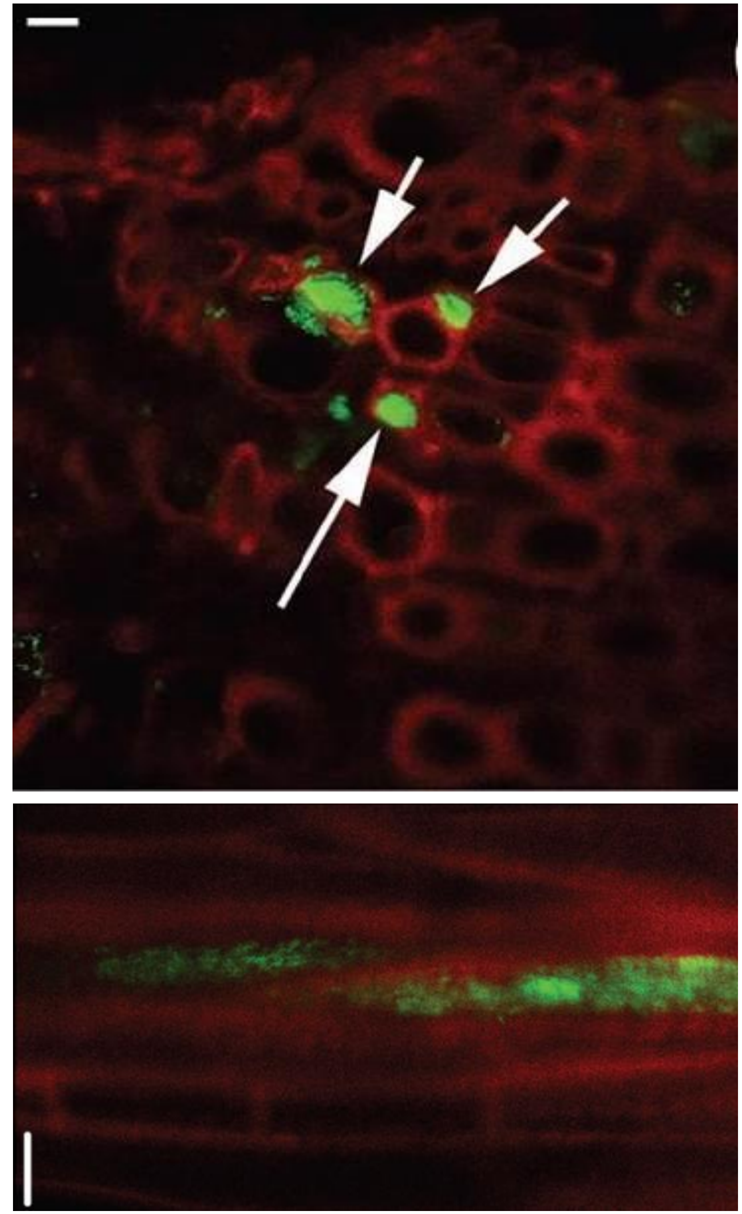
…but, ***Xylella* does not cause significant disease in most hosts**

What causes the onset of *Xylella* disease symptoms?

1. Vessel occlusion
   - bacterial aggregates
   - plant defensive response

2. "Phytotoxin"
   - candidate toxins being studied

3. Environmental trigger
   - water stress exacerbates onset of symptoms
   - symptoms most severe late Summer or Fall



Agriculturally important *Xylella* diseases

- Alfalfa dwarf
- Almond leaf scorch
- Blueberry leaf scorch
- Citrus variegated chlorosis
- Coffee leaf scorch
- Pear leaf scorch
- Pecan leaf scorch
- Pierce’s disease
- Phony peach disease
- Plum leaf scald

……

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……

Olive quick decline syndrome

Bacterial leaf scorch in East Coast shade trees

Ornamental trees in California

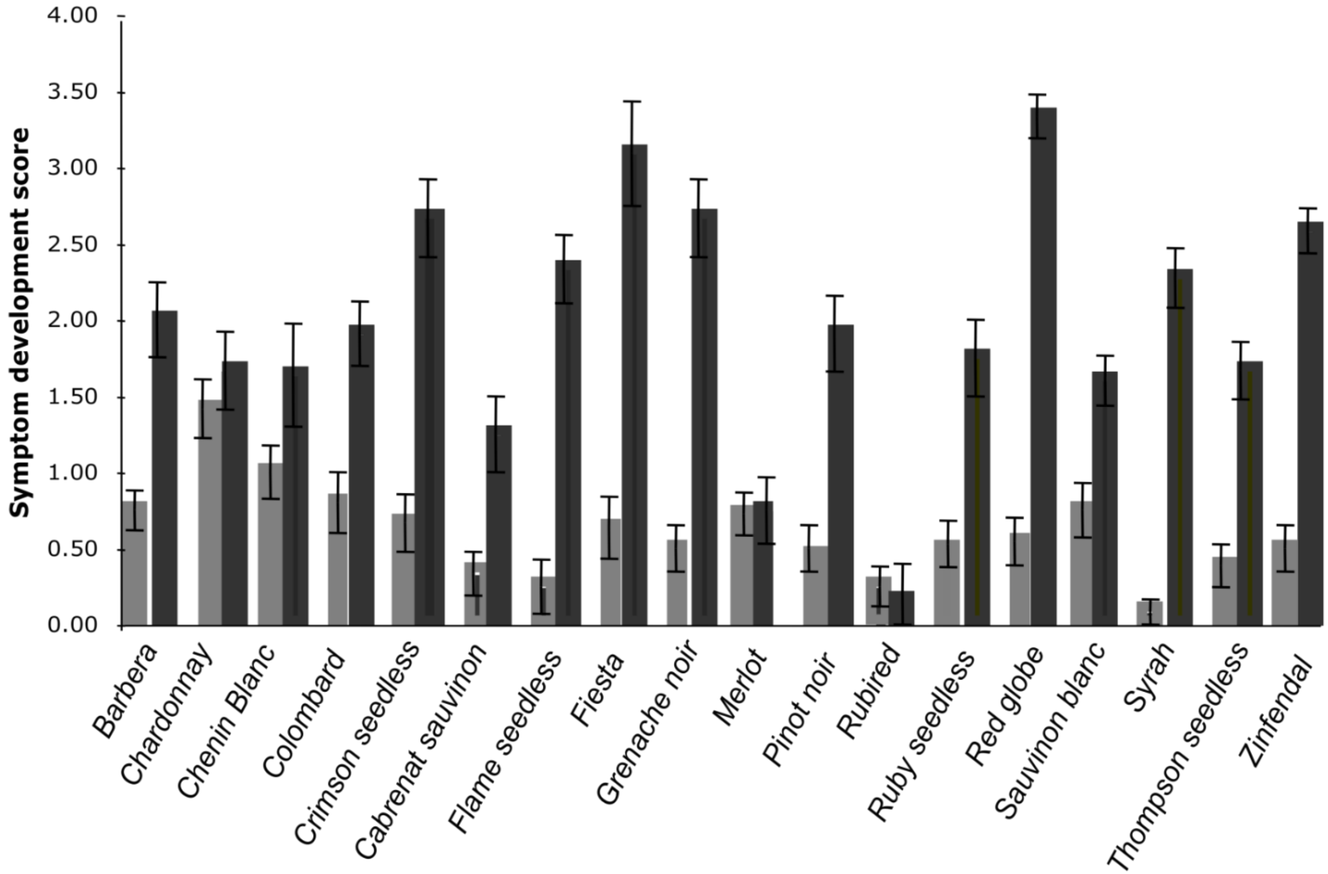
Other ornamental hosts

Xylella diseases differ in their pace

- infections can be detected within weeks in grapevines, with plants potentially dying within 1 season

- infections take months to detect in coffee and it may take 2 years before symptoms are apparent

Different plant species/cultivars can differ substantially in susceptibility to *Xylella*

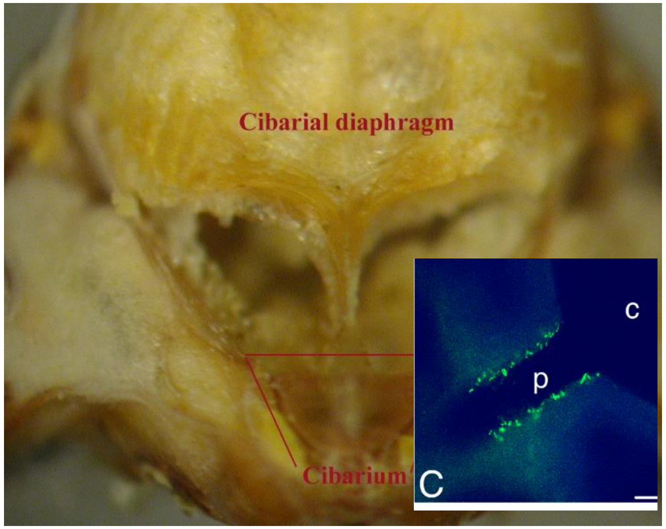


- different *V. vinifera* cultivars vary in infection level and symptom severity

Xylella fastidiosa transmission

Transmitted by xylem sap-feeding insects

- some leafhoppers, spittlebugs



No transovarial transmission

No latent period

Nymphs & adults can transmit

- no transmission after molting
- persistent in adults

Vector species differ in efficiency

- depends on *Xylella* strain, host plant

Which vectors are most important in California?

Glassy-winged sharpshooter

- not efficient, can reach high densities
- present only in S. CA, S. Central Valley

Blue-green sharpshooter

- entire coast range (Mexico to Canada)
- very efficient

Other native sharpshooters

- green, red-headed, smoke tree
- low to moderate efficiency, moderate densities

Glassy-winged sharpshooter (*Homalodisca vitripennis*)

Native to SE USA

First documented in CA in 1989

Spread throughout S. CA, S. Central Valley, select areas further North

Extremely broad host range

-350+ plant taxa on CDFA list

https://www.cdfa.ca.gov/pdcp/Documents/HostListCommon.pdf

Relatively inefficient vector of *Xylella*

Glassy-winged sharpshooter (*Homalodisca vitripennis*)

Relatively inefficient at transmitting *Xylella*, but…

- more active throughout the year
- willing to feed on woody plant material
- able to fly further than other vectors
- capable of very high population growth rates
- broad host range meant its invasion was followed by several new *Xylella* diseases

Xylella is genetically diverse

Native to Americas (Costa Rica, US, Brazil)

Genetically differentiated into multiple strains/subspecies

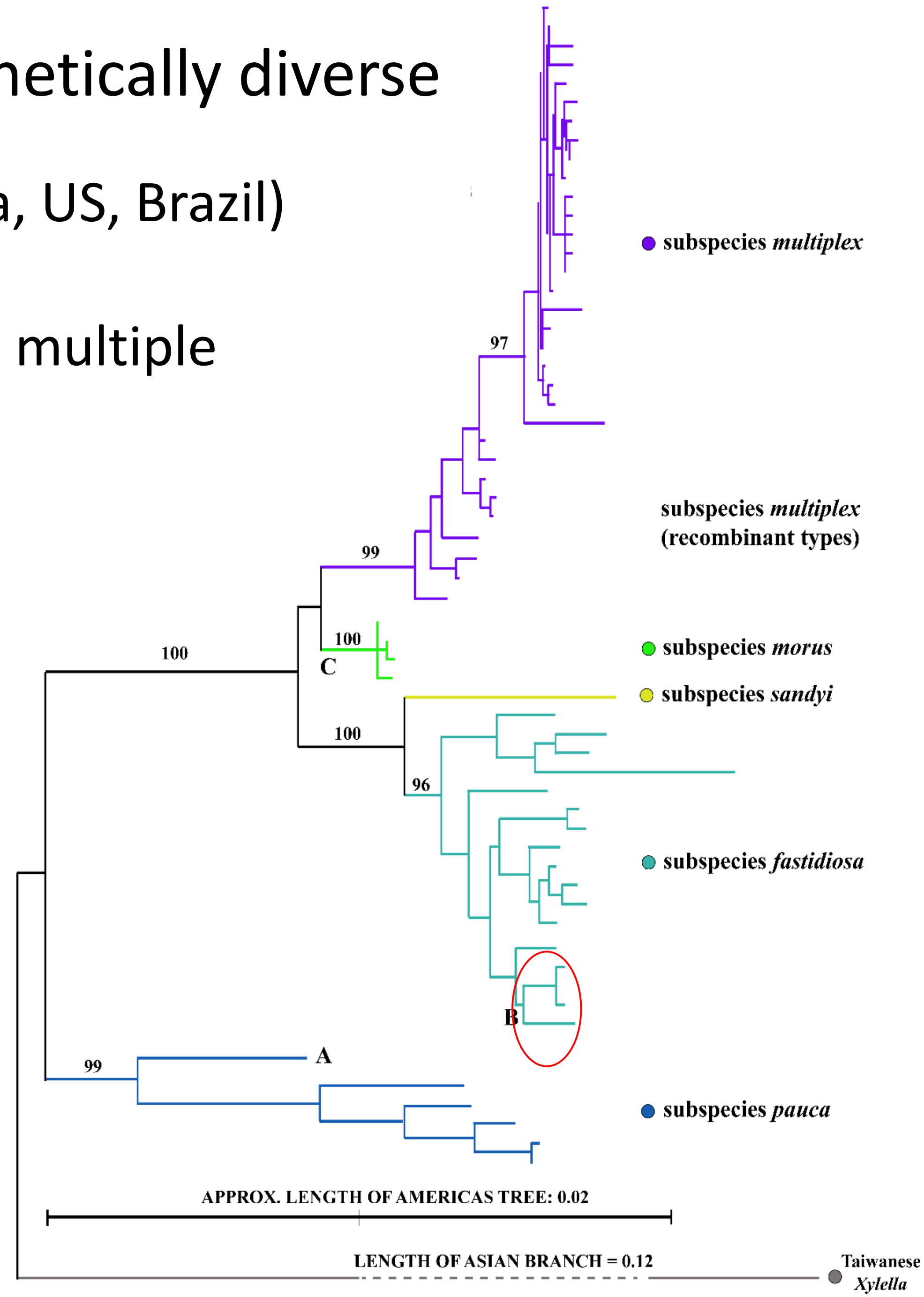
subsp. *fastidiosa*

subsp. *multiplex*

subsp. *sandyi*

subsp. *pauca*

subsp. morus



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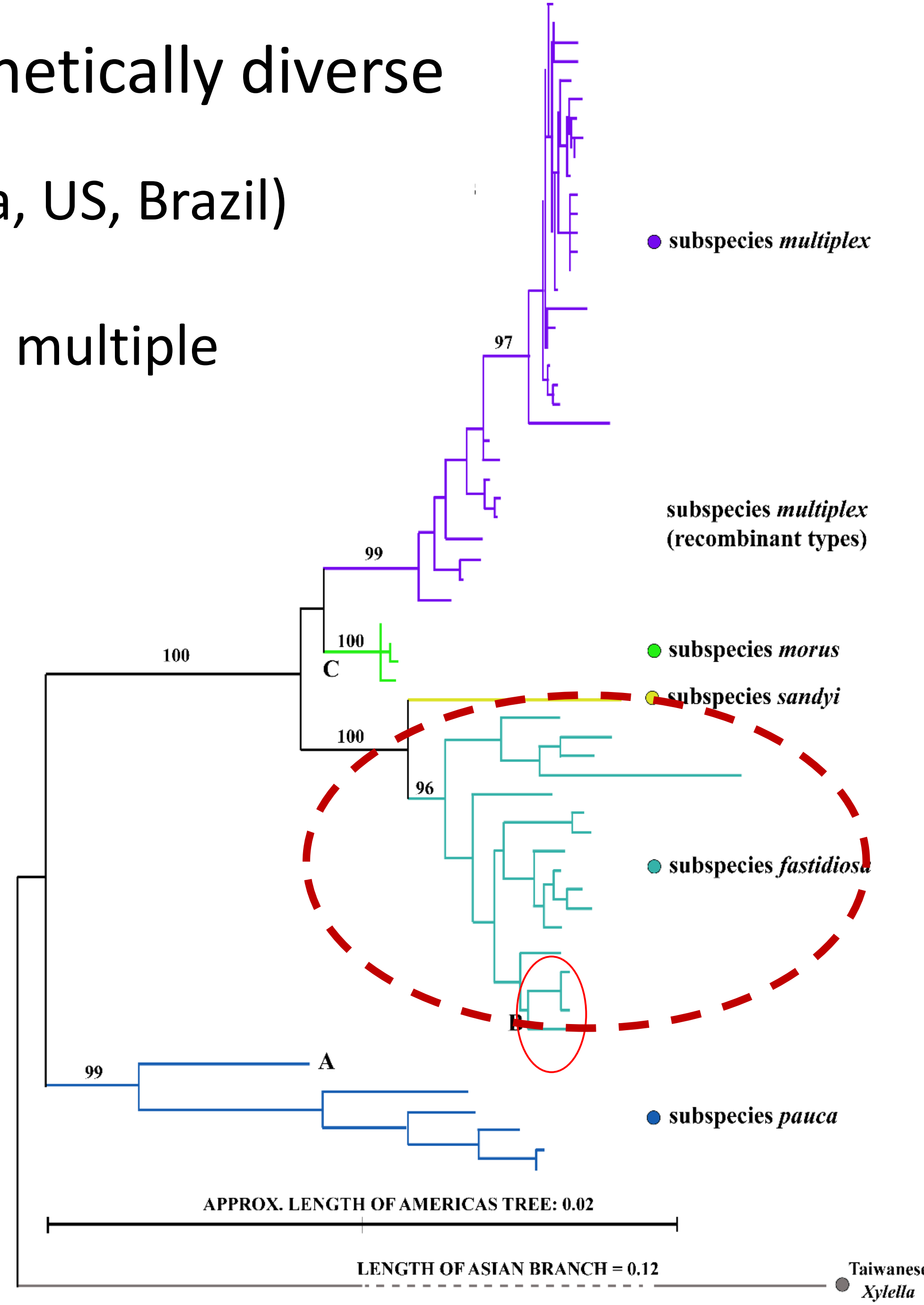

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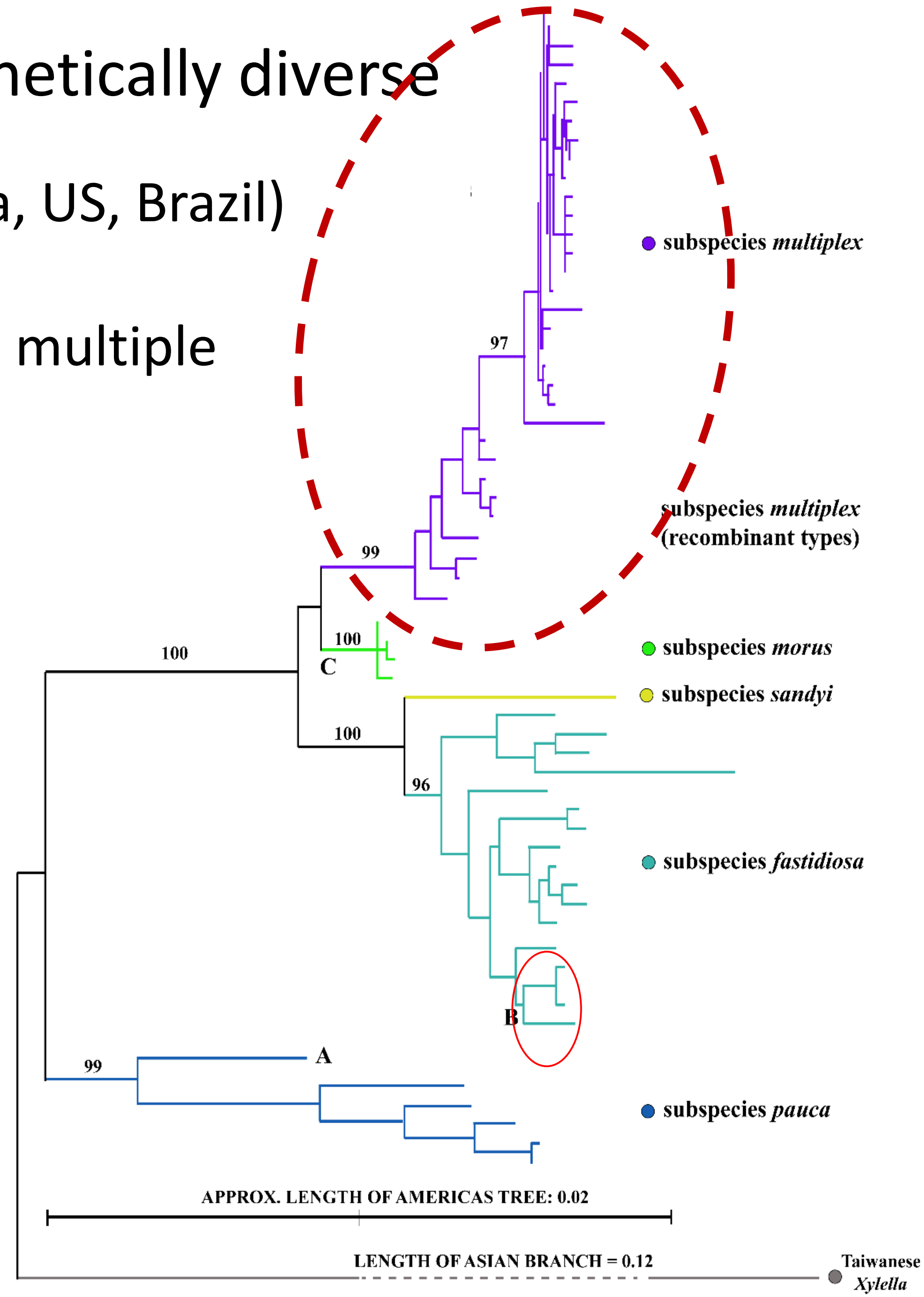
- Alfalfa leaf scorch
- Bacterial leaf scorch

subsp. *sandyi*

subsp. *pauca*

subsp. morus



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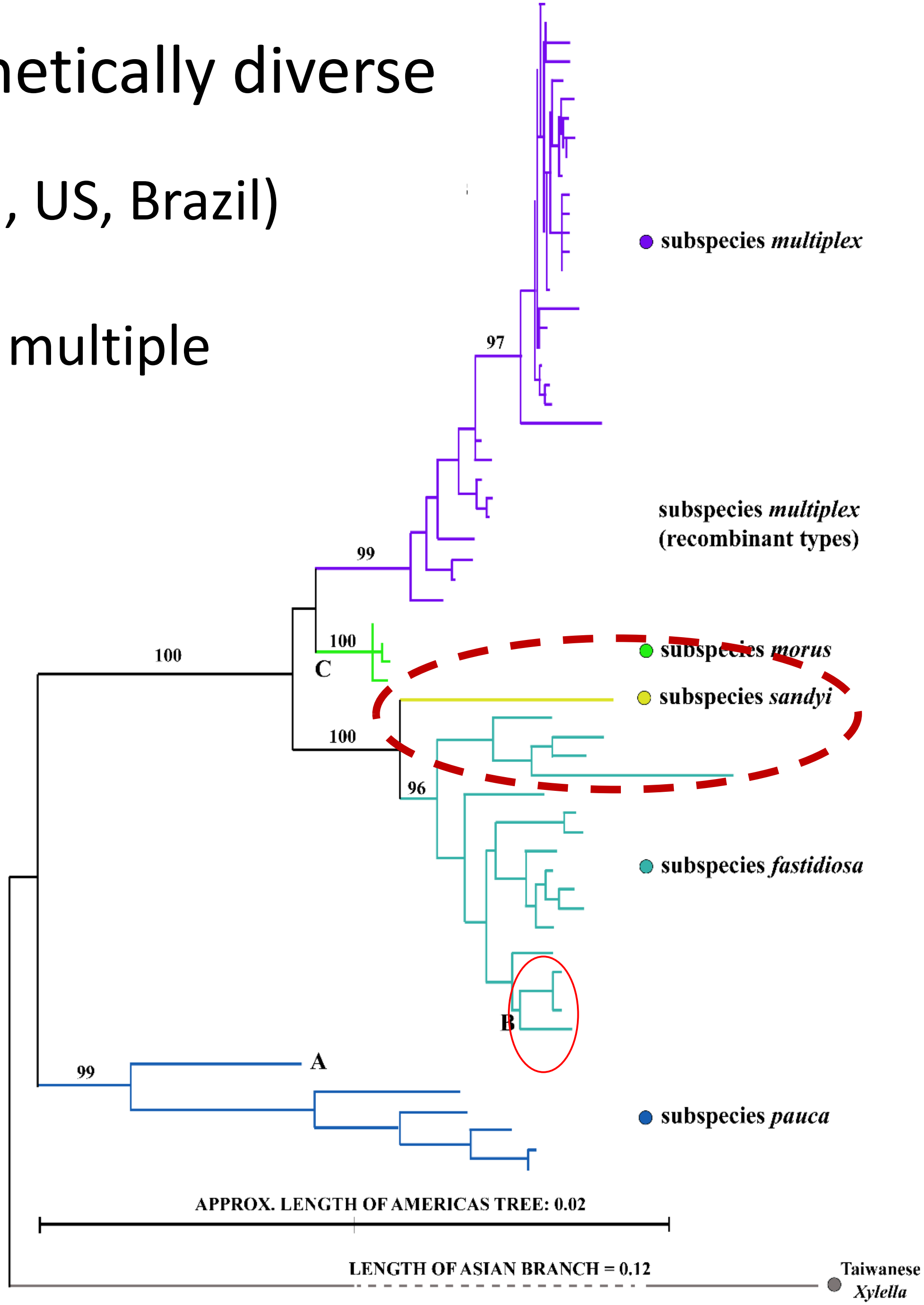
- Oleander leaf scorch

subsp. *pauca*

subsp. morus



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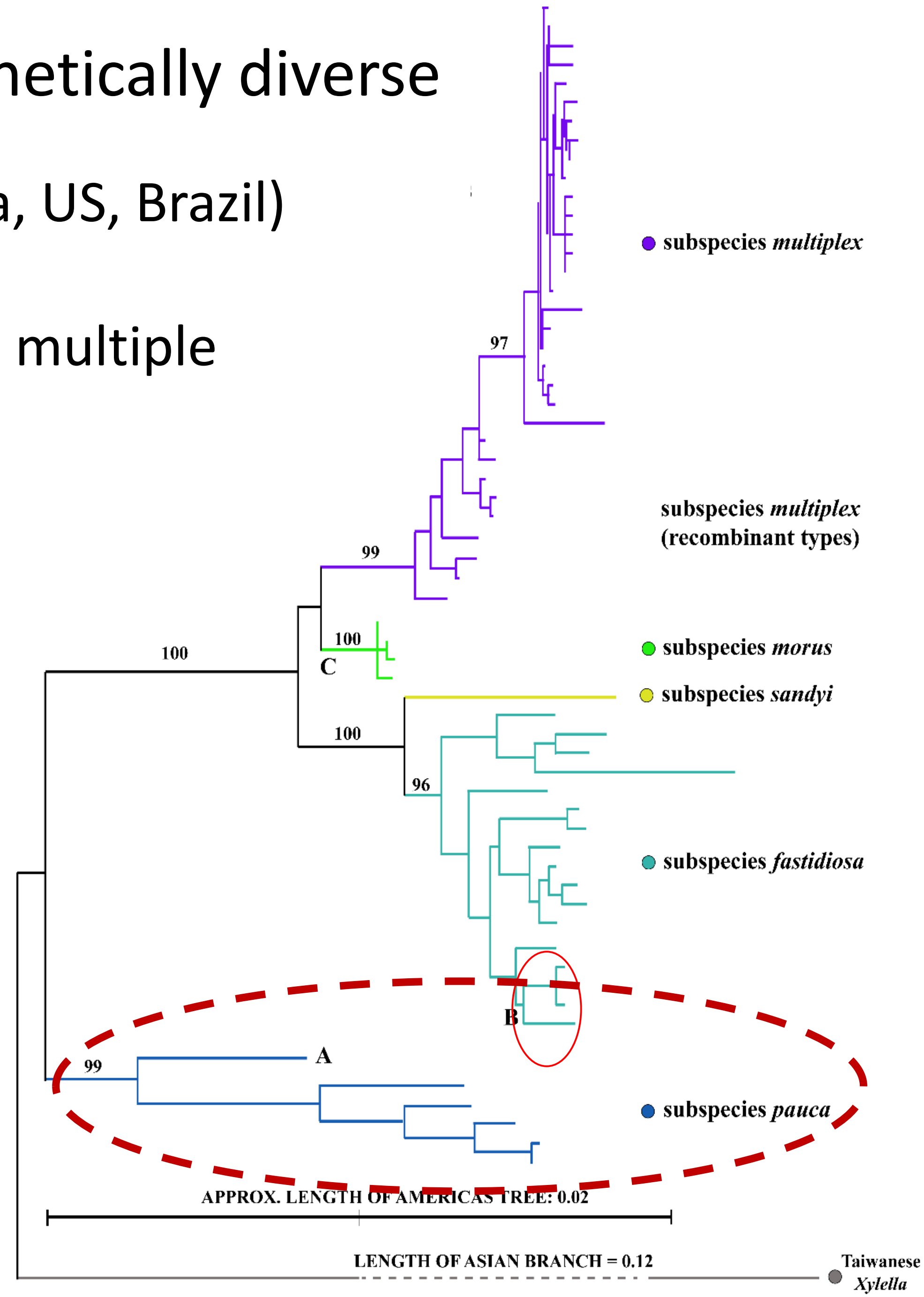
- Citrus variegated chlorosis
- Coffee leaf scorch
- Olive quick decline

subsp. morus



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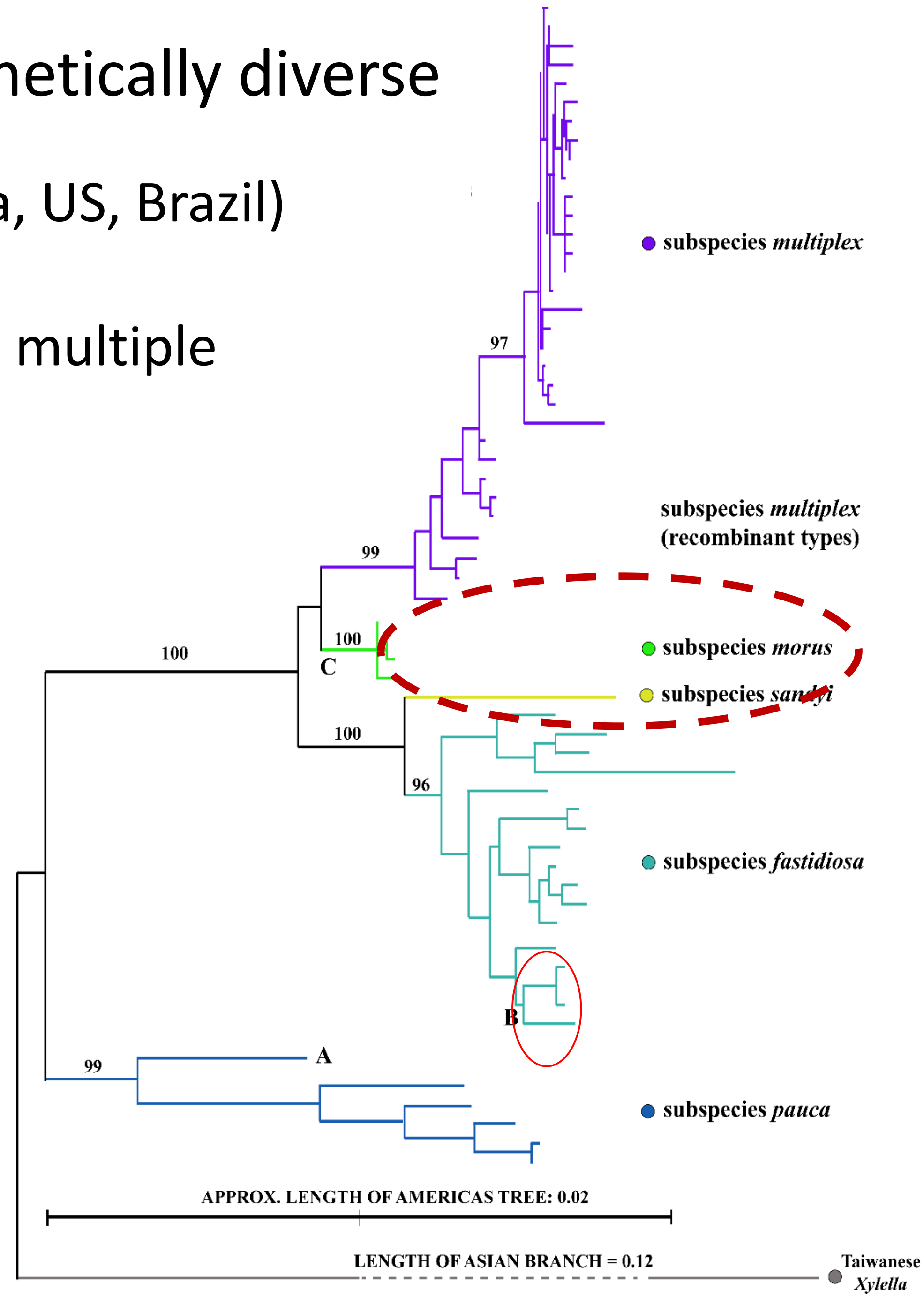
subsp. morus

- Mulberry leaf scorch
- Bacterial leaf scorch

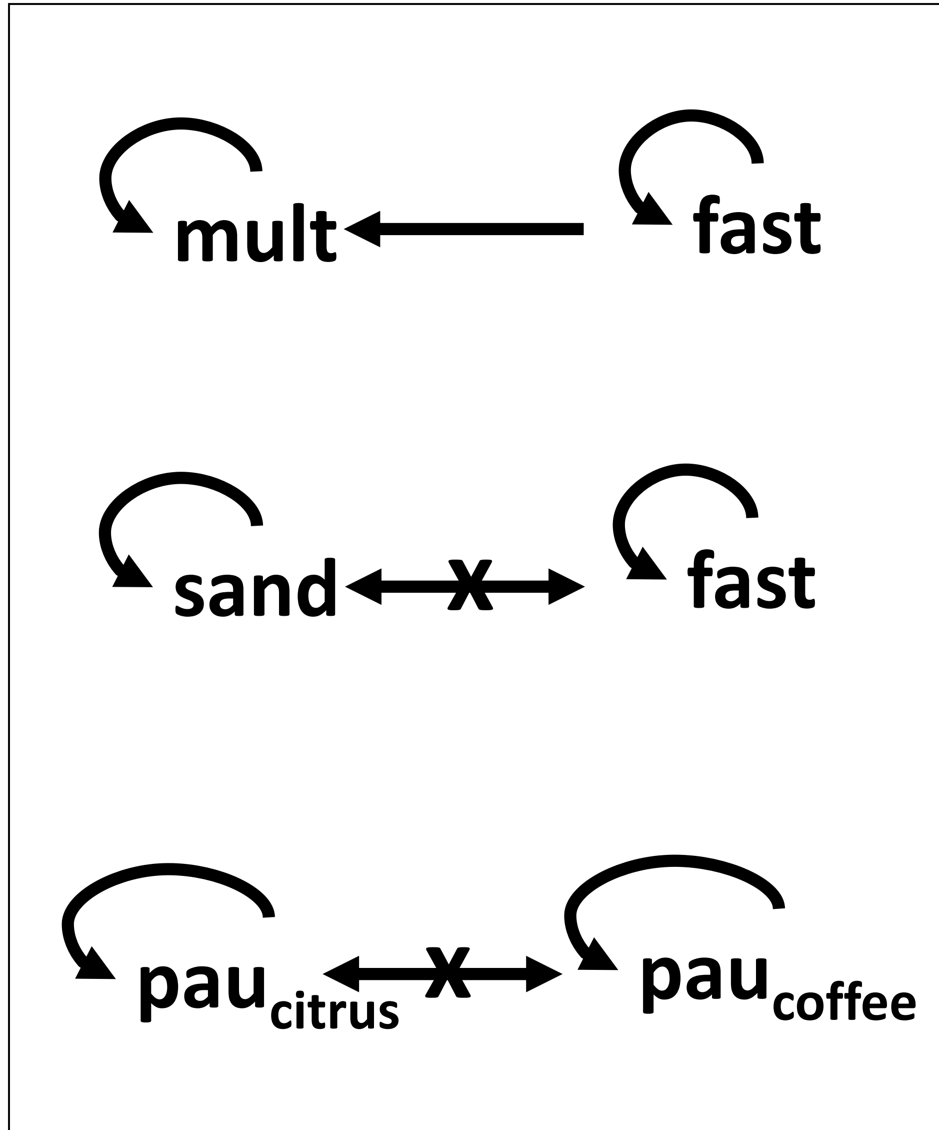


Xylella is biologically complex

Infection ≠ disease

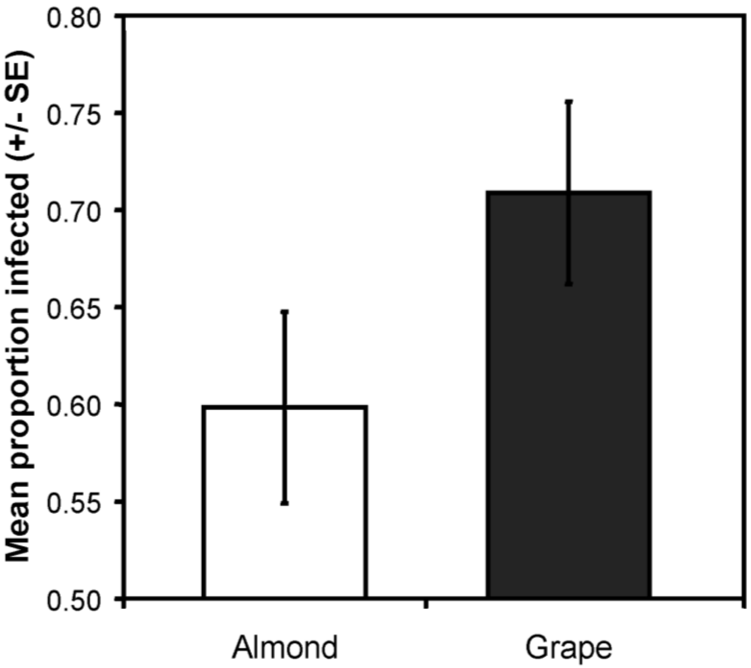
- not all strains cause disease in other hosts

- even closely related strains may not be equivalently virulent



Strain variability for alfalfa dwarf

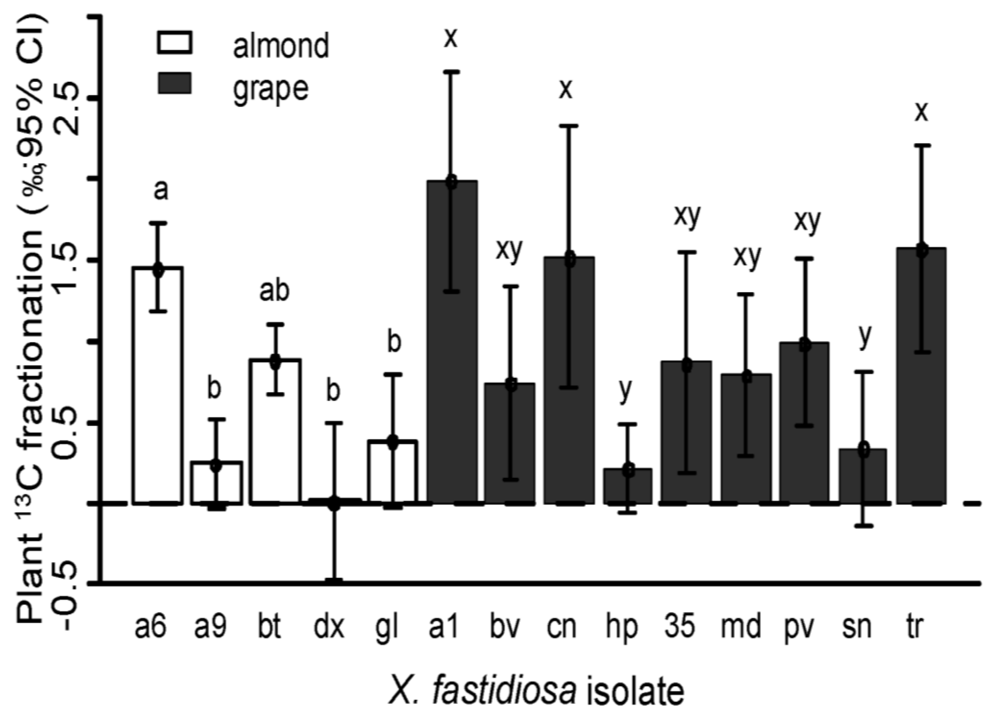
- alfalfa is susceptible to both subsp. *fastidiosa* and *multiplex*
- subsp. *fastidiosa* is more virulent than *multiplex*

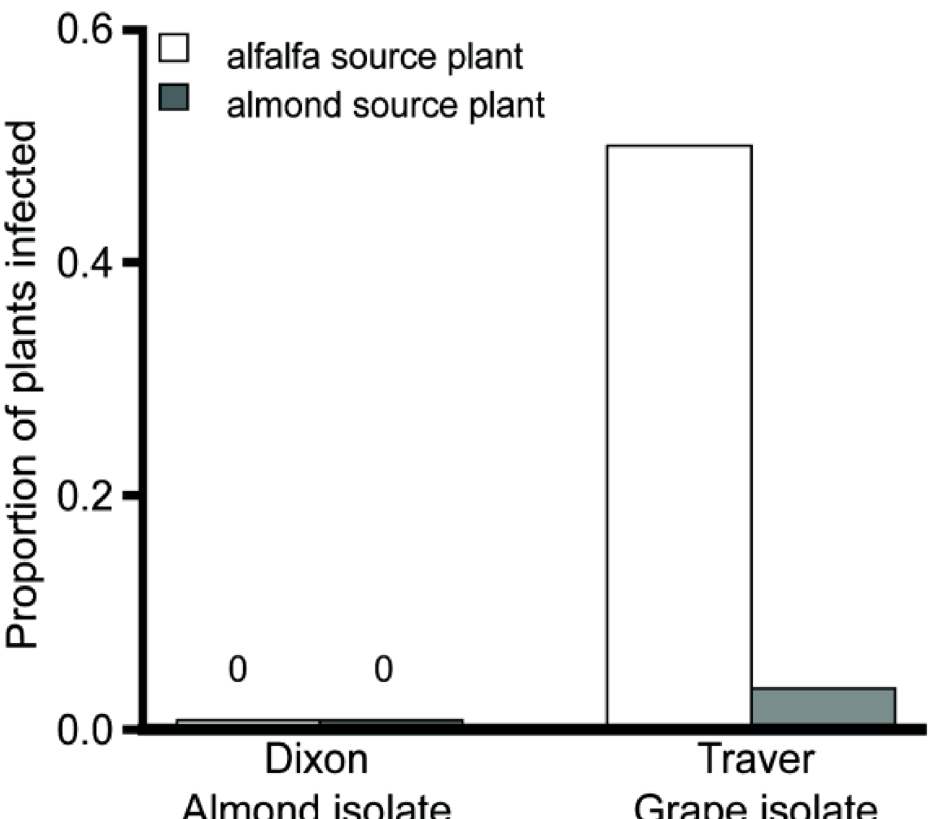


- subsp. *fastidiosa* produce higher infection rates

- subsp. *fastidiosa* causes more severe water sress

- virulence of isolates within a strain can differ a lot





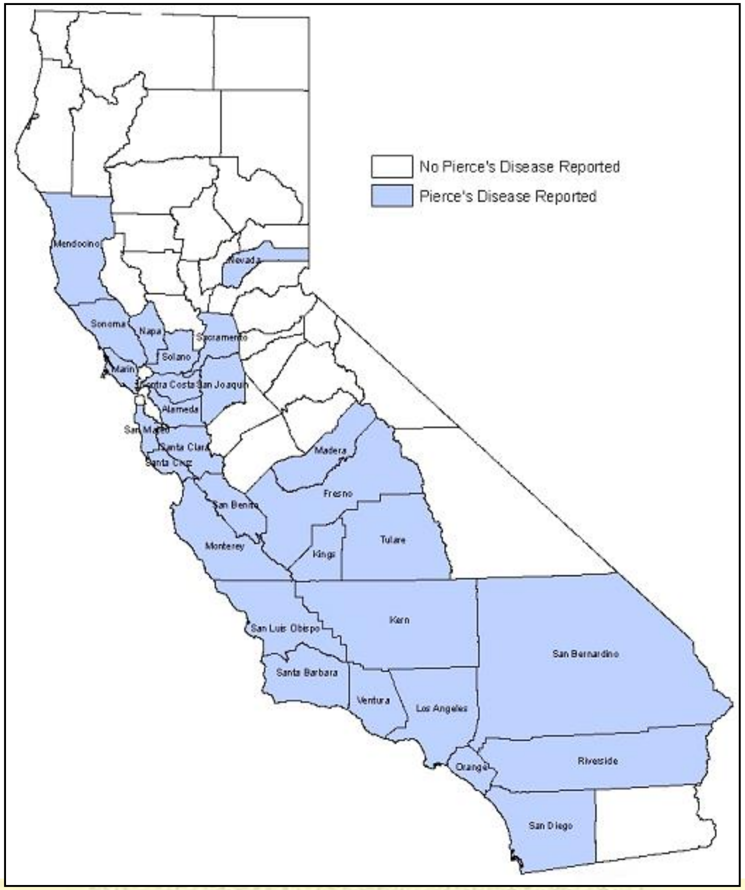
Xylella transmission by vectors is context-dependent

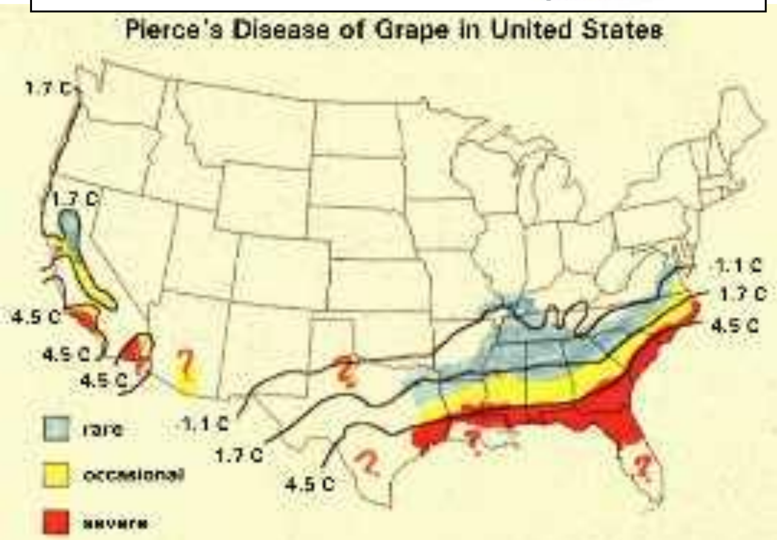
Transmission depends on:

- host plant type
- *X. fastidiosa* strain

Acquisition rate determined by infection level

- wimpy host-strain combos not likely to be picked up





Xylella is widely distributed

Present in Coastal areas of US, where there aren't hard freezes in the winter

Prevalent throughout California, except

- mountains, far North?

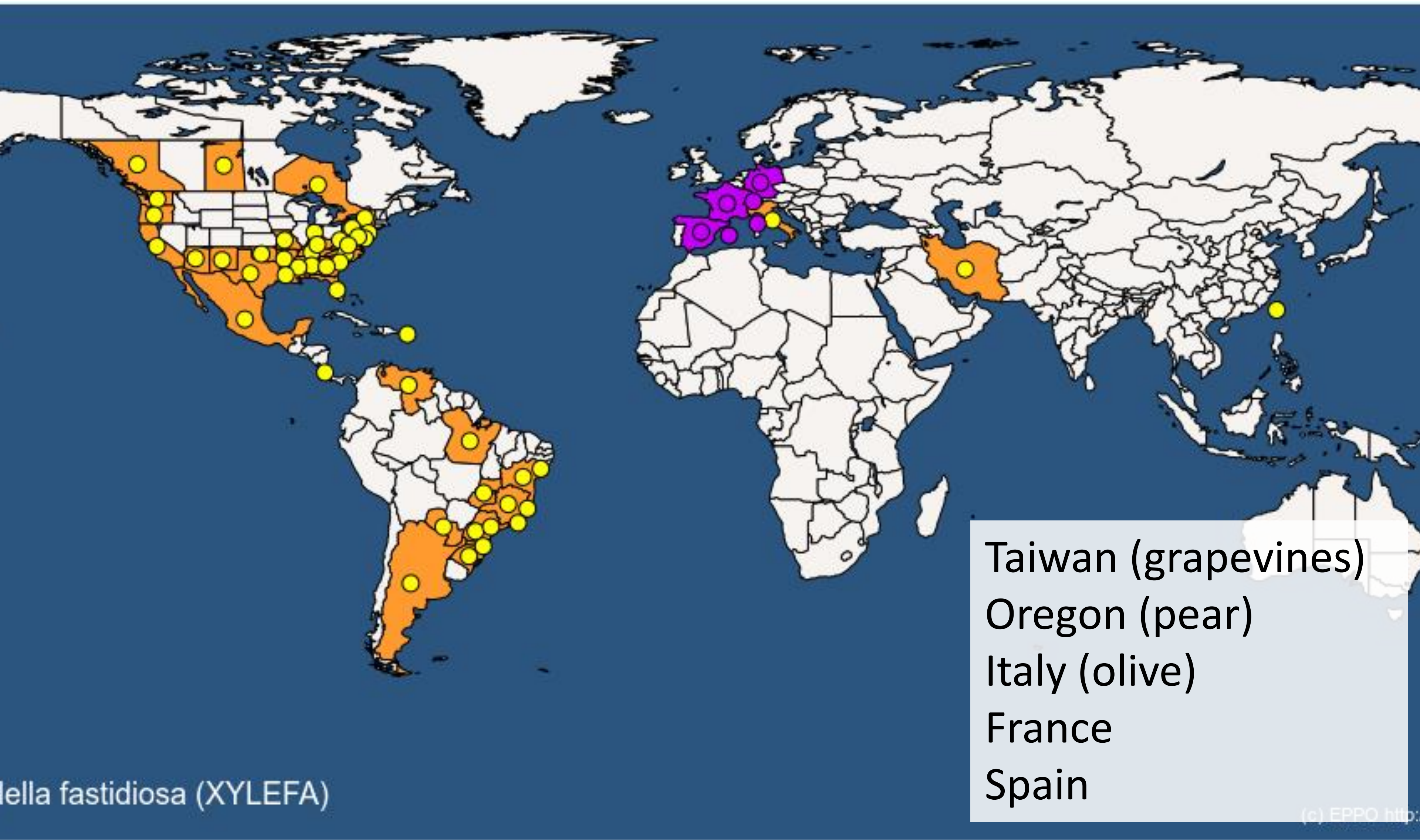
AZ, Gulf states, up to Virginia

Costa Rica

Brazil

Xylella is widely distributed

Continues to be found in new areas

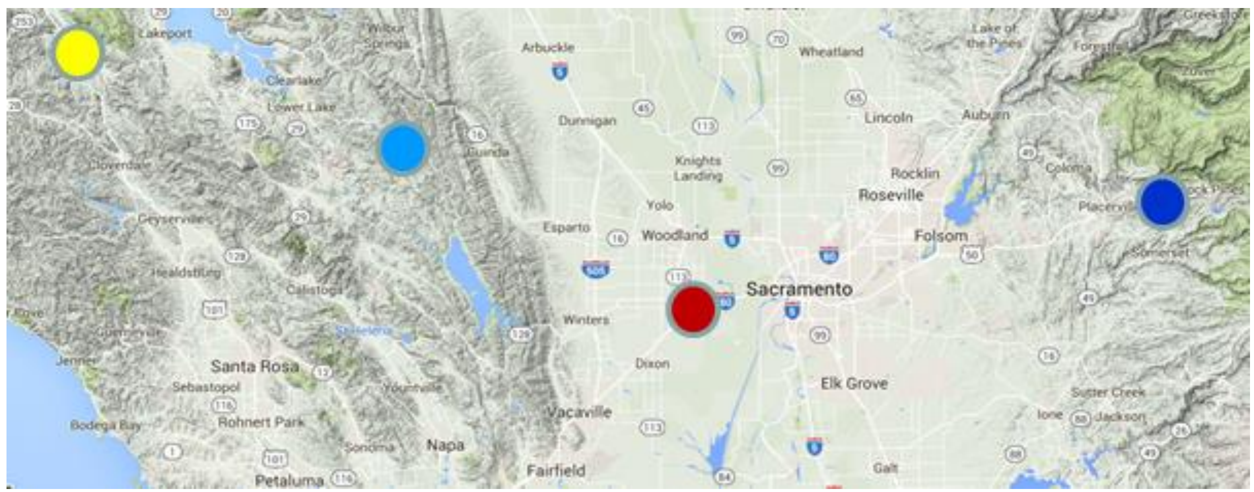


Taiwan (grapevines)
Oregon (pear)
Italy (olive)
France
Spain

Why is Xylella limited to where it is? - Climate

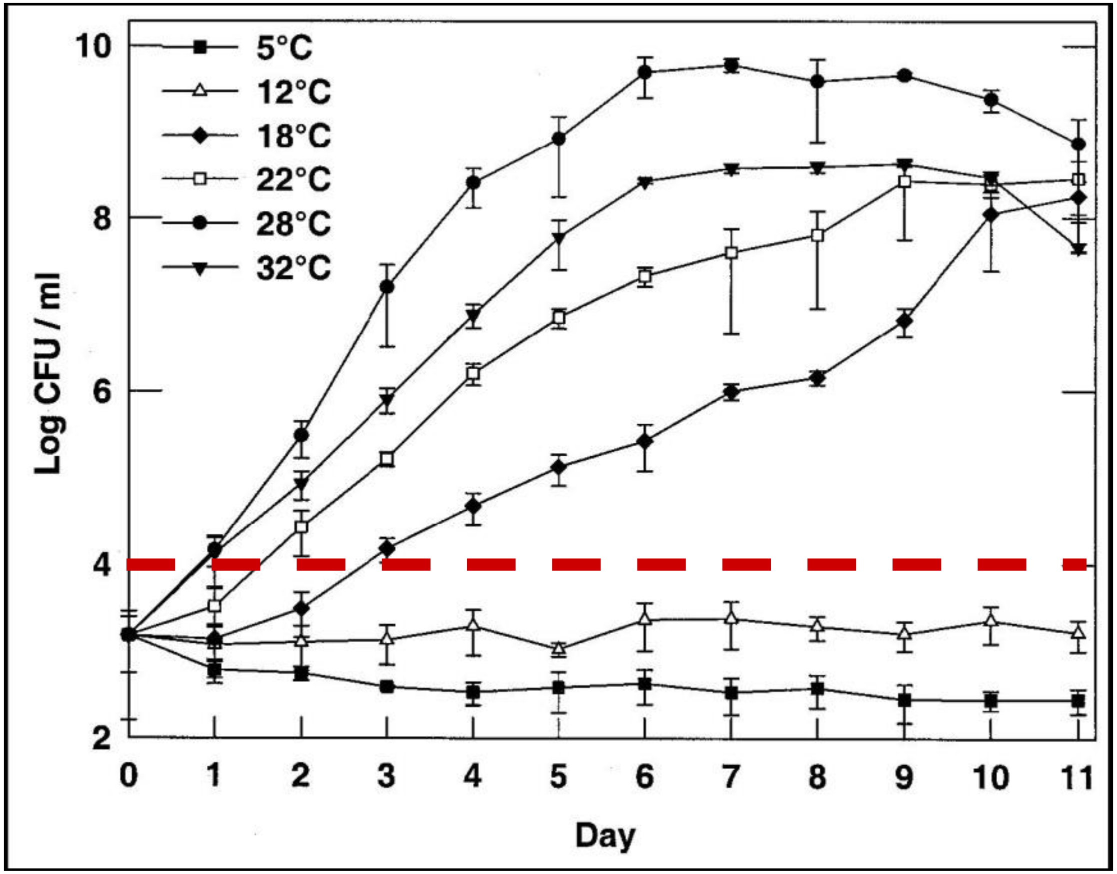
Infected plants can recover over the winter

- “cold curing“ over the winter depends on # days below 40°F

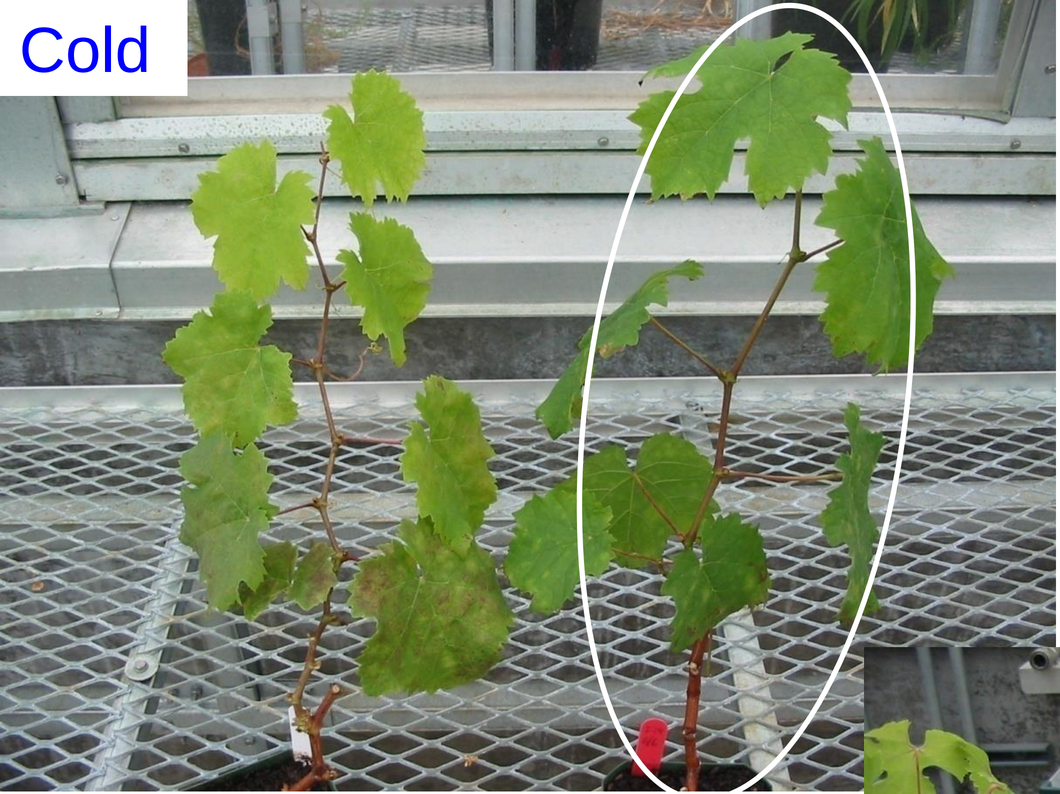


Lieth et al. 2012

Station name	Location (latitude, longitude)	Levels of cold curing (C): Pinot Noir 2007–08	Pinot Noir 2008–09	Cabernet Sauvignon 2007–08	Cabernet Sauvignon 2008–09
Davis	N38°32′09″, W121°46′32″	0.44	0.50	0.00	0.00
Hopland	N39°00′25″, W123°04′45″	1.00	1.00	0.63	0.92
McLaughlin (Knoxville)	N38°49′40″, W122°20′26″	1.00	1.00	0.89	1.00
Foresthill (Camino)	N38°45′13″, W120°43′57″	1.00	1.00	1.00	1.00

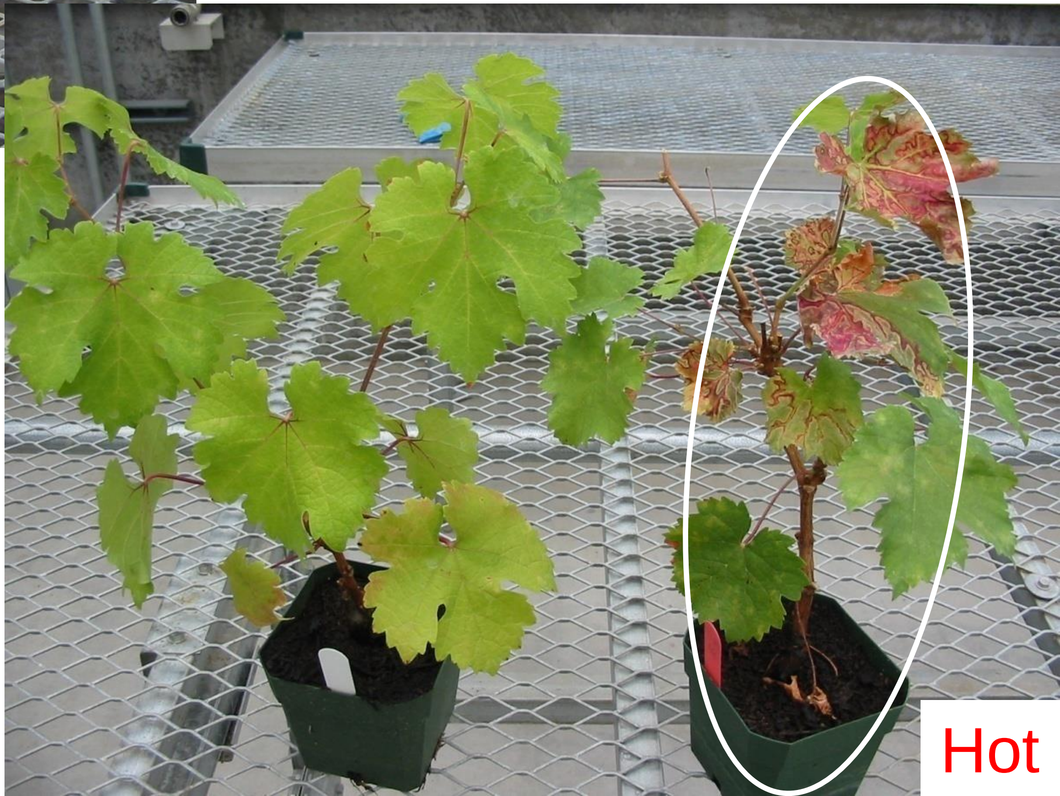


-*X. fastidiosa* growth depends on temperature



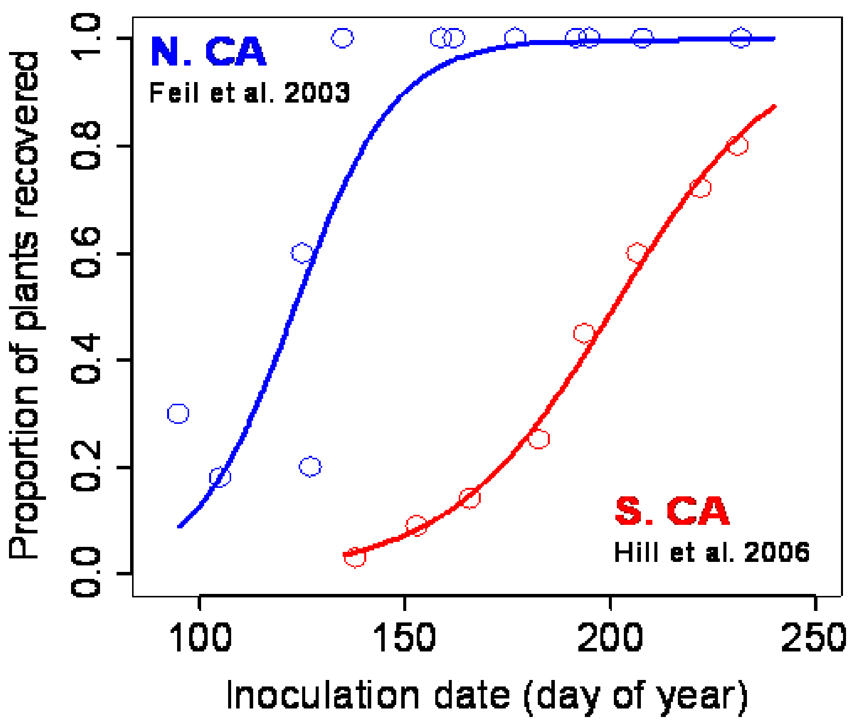
-mean daily min/max:
17/24°C

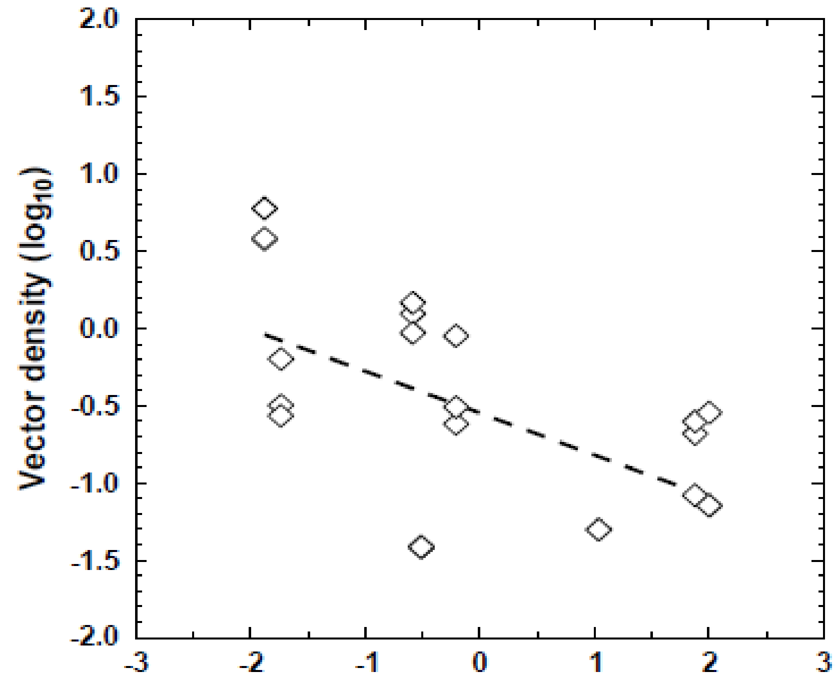
-mean daily min/max:
21/36°C



Warmer climates typically have more severe PD epidemics

- lower overwinter recovery, higher pathogen multiplication
- greater vector population densities





warm, wet winter

cold, dry winter

Factors that aid/undermine PD management

+ vectors must acquire from infected plant to be infective
+ pruning is not an important source of *Xylella* spread
+ no evidence of root-graft transmission
+ cold winters encourage recovery of some vines

- can't prune out PD infections
- resistant/tolerant varieties not yet available
- no therapeutic cure for infected vines

PD management relies on 1) suppressing vector populations and 2) limiting pathogen supply

What happened in Temecula Valley?

By late 90s extremely high GWSS populations

- ”100s to 1000s” per vine
- proximity to citrus

Severe Pierce’s disease outbreaks

- up to 100% infection within a year

~40% loss for Temecula region

Similar epidemic in S. Central Valley in early 2000s

Response to GWSS-mediated PD outbreaks

Area-wide vector control

1. sharpshooter monitoring
2. biological control
3. chemical control in citrus

Quarantines on plant material

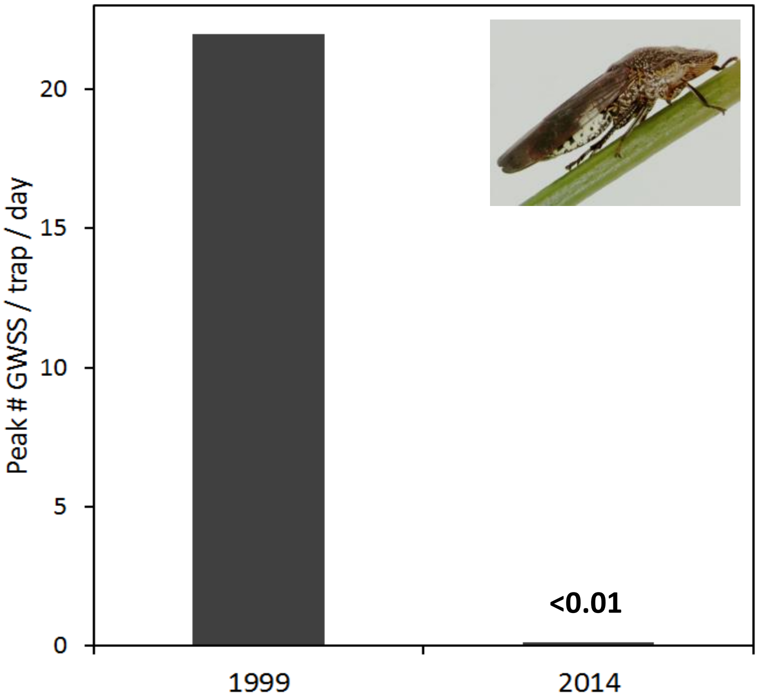
- limit transport of GWSS

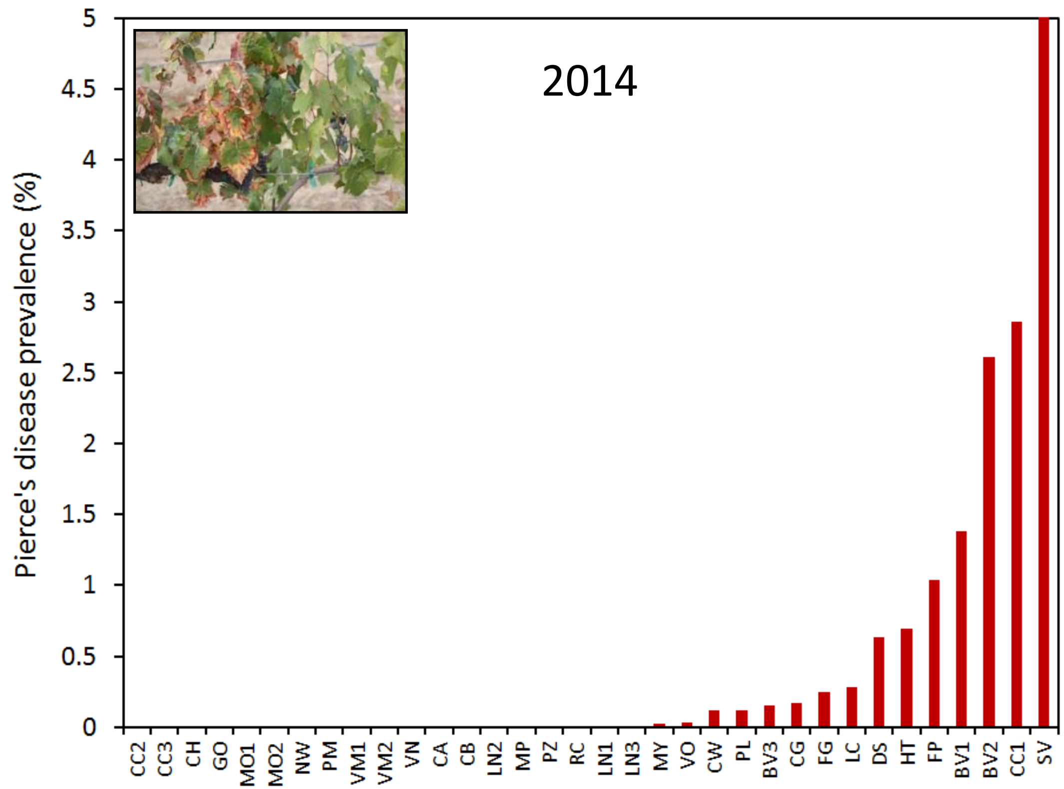
Vineyard management

- vector control
- removal of disease vines
- weed management

Effectiveness of GWSS & PD management

GWSS populations greatly reduced compared to 15+ years ago



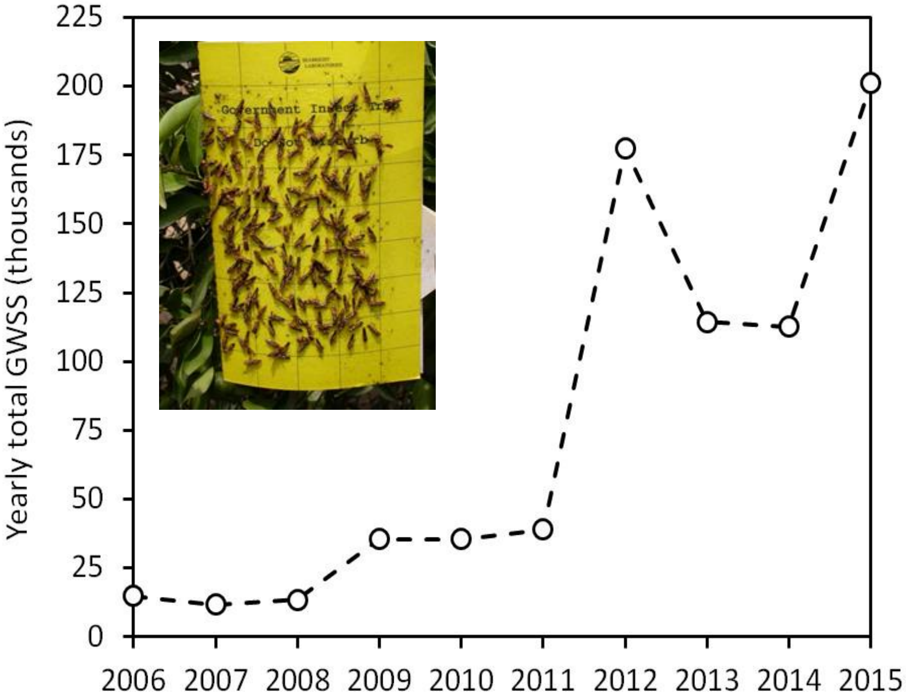


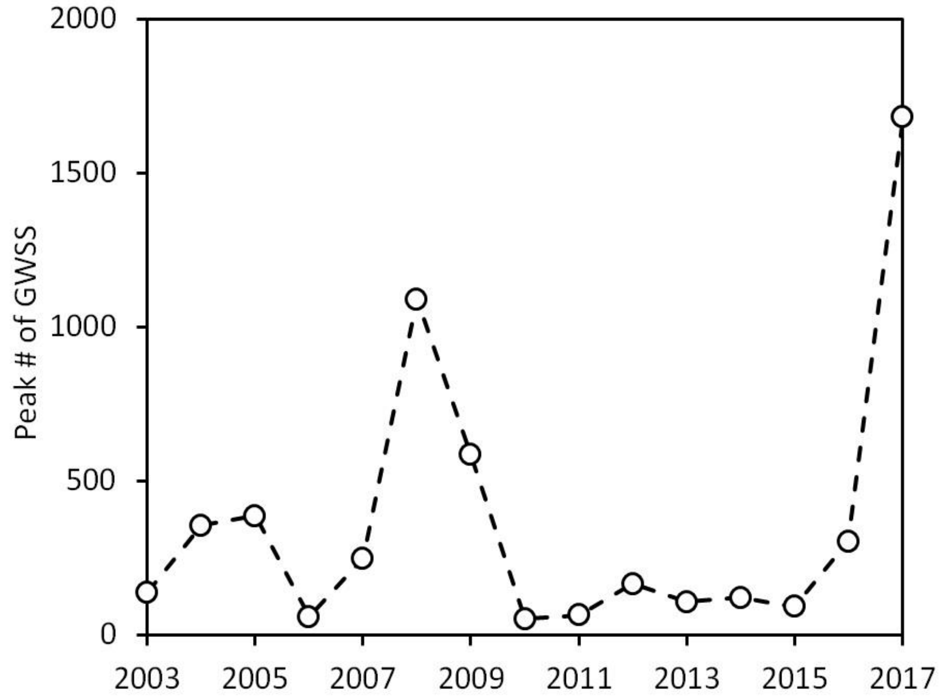
Pierce's disease prevalence is also substantially reduced

<1% on average, majority of blocks had no PD

A GWSS resurgence?

After several years of low densities, GWSS populations are starting to rebound in certain areas



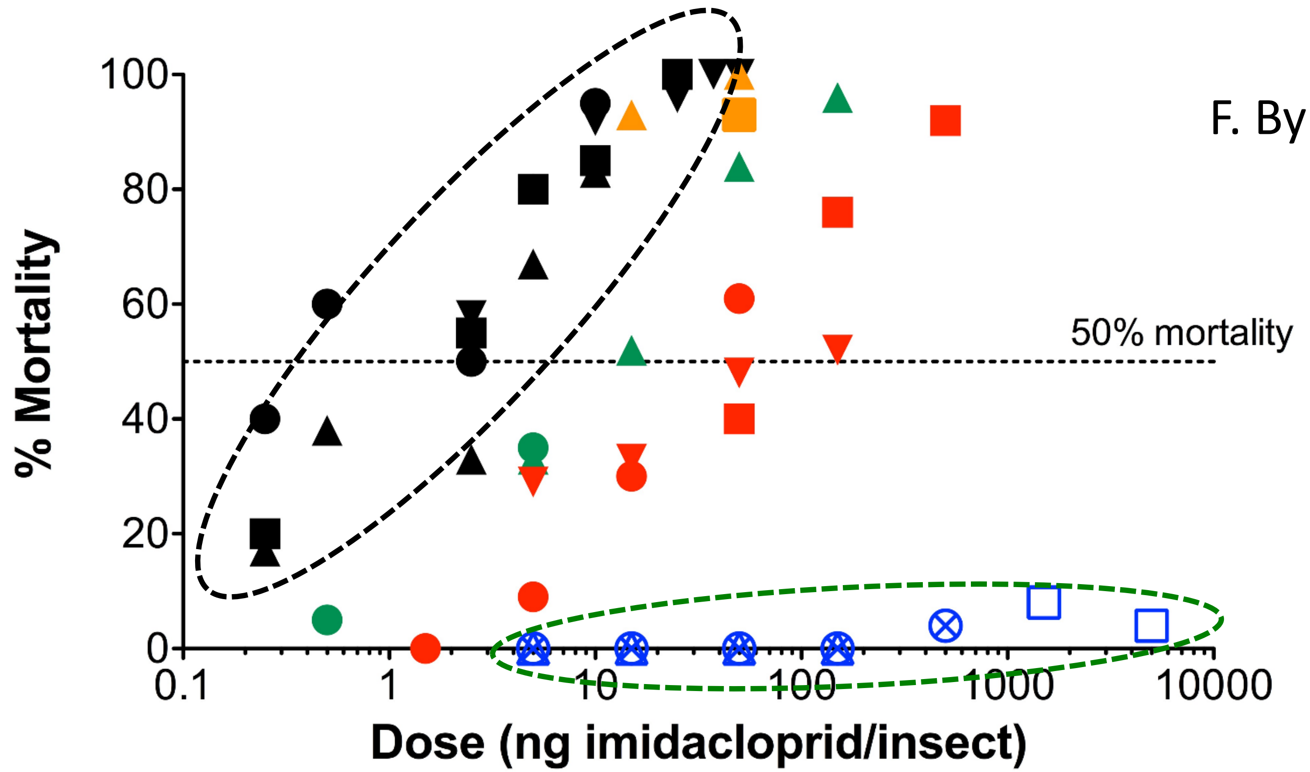


- Kern and Tulare Co. GWSS more than 8-fold higher since 2011
- In Temecula peak catch in 2017 was greatest in 15 years

GWSS insecticide resistance

Ongoing research is evaluating GWSS susceptibility to systemic neonicotinoids and pyrethroids

F. Byrne, UCR



Current Kern Co. GWSS are 1700 times less susceptible to imidacloprid!

Pierce's disease management

1. Vector control
    - chemical control (conventional and organic)
    - biological control (egg parasitoids)
    - barriers to vector movement

2. Eliminate inoculum supply
    - remove infected vines (e.g., roguing)
    - eliminate reservoir hosts (e.g., riparian corridors)

3. Host resistance
    - resistant hybrids, transgenics
    - anti-microbial treatments, bacteriophage, avirulent strain

http://www.cnr.berkeley.edu/xylella/

http://www.ipm.ucdavis.edu/PMG/r302301711.html

http://www.piercesdisease.org/

https://gd.eppo.int/taxon/XYLEFA/