Emerging Pests and Diseases

In Northern California Vineyards

Christopher Chen, Ph.D.
UCCE – Integrated Vineyard Systems Advisor
Sonoma | Mendocino | Lake

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History of Vineyard Pests

- Vineyard pests have always been an issue
- The three that exist in 19th century records most often are:
    1. Powdery Mildew
    2. Downy Mildew
    3. Grape Phylloxera
- We still deal with these pest pressures today
- Now there are "new" pests

Major Current Pests of Vineyards

- **Insect**
  - Hoppers
  - Mites
  - Beetles
  - etc.
- **Fungal**
  - Trunk
  - Roots
  - Foliar
  - Vascular
- **Bacterial**
  - Vascular
  - Ice-Nucleating
- **Viral**
  - "Red Leaf" = GRBaV | GLRaV
  - GFLV
  - etc.
- **Animal**
  - Mammals
  - Birds
  - Worms
  - etc.
- **People?**
  - (Just kidding)

"New" Pests and Diseases

- Is it new to science, new to the region, or both?
  - "New" = New to science or new functional ranges
  - "Invasive" = New to a region with few checks on growth
- Has is been present already and missed or misidentified?
- Well-known examples:
  1. Grape Phylloxera
     - Unknown in 18th century
     - Killed many vineyards
     - Thomas Jefferson repeatedly planted vineyards that died to Grape Phylloxera; he never knew what the cause of vine mortality was
  2. GRBaV
     - Symptoms misidentified as GLRaV
     - Not identified as separate virus until 2008 (in Oakville, CA)

'New' Pests & Diseases in vineyards

Often can be difficult to identify:

- Lyme disease on the West Coast or GRBV in vineyards

Grapevine Red-Blotch Associated Viruses

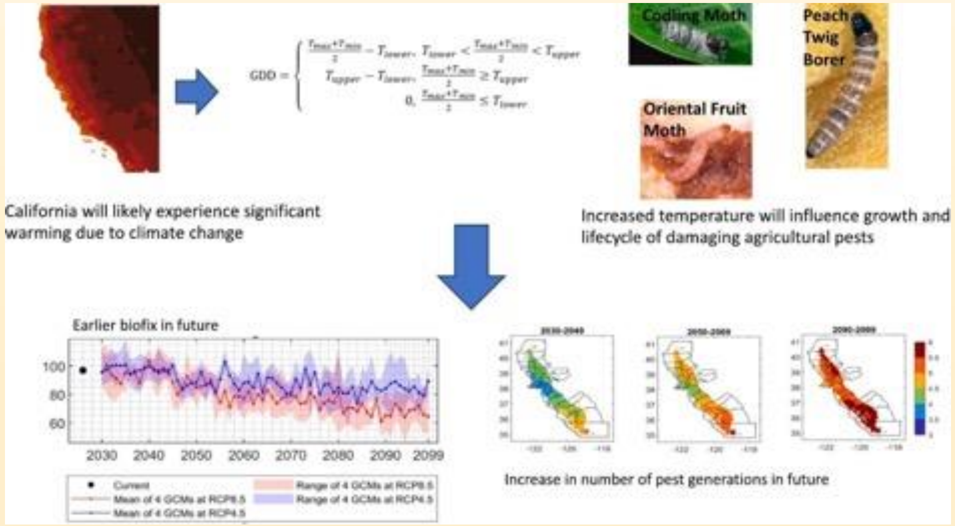
- Flagship example for grapevines
- Not known until 2008 (Oakville, CA)

"Invasive" Pests and Diseases in Vineyards

- The pest is "known" to science
  - It exists and has been identified somewhere in the world
- It likely has some predation or parasitic pressure in its native range that keep populations in check
- When introduced to a new region it reproduces rapidly with little-to-no checks on population growth
- Often outcompetes similar, native species

Emerging Pests ~ Climate Change

- Many emerging vineyard pests are "new" to a region and may also become "invasive" if allowed to establish
- This movement is related to changes in average, ambient temperatures and precipitation patterns [+]
- Pest movement has also been aided by modern transportation and shipping



[+] Kumar Jha et al. 2024

[+] Kumar Jha et al. 2024

Pest and disease responses to climate change

As a result of the indirect impacts of:

1. Increased **average temperatures**
2. Increased **winter temperatures**
3. Changes in **developmental timing** of predators/parasitoids
4. Changes in **distribution and range of host plants**

We should monitor for changes in:

1. Pest and disease geographical ranges
2. Over wintering success
3. Species interactions
4. Effectiveness of pest predators and parasitoids

Insect responses to climate change

Insects can respond to climate change in several ways, however three major responses that have been cited are [1] :

1. Moving to a climate more suitable to them
2. Shifting their phenology to correspond with the local changes in environmental conditions, or
3. Adapt to the new conditions and the associated impacts on the ecosystem

1. Pureswaran, et al., 2021.

Climate change impacts on vineyard pests

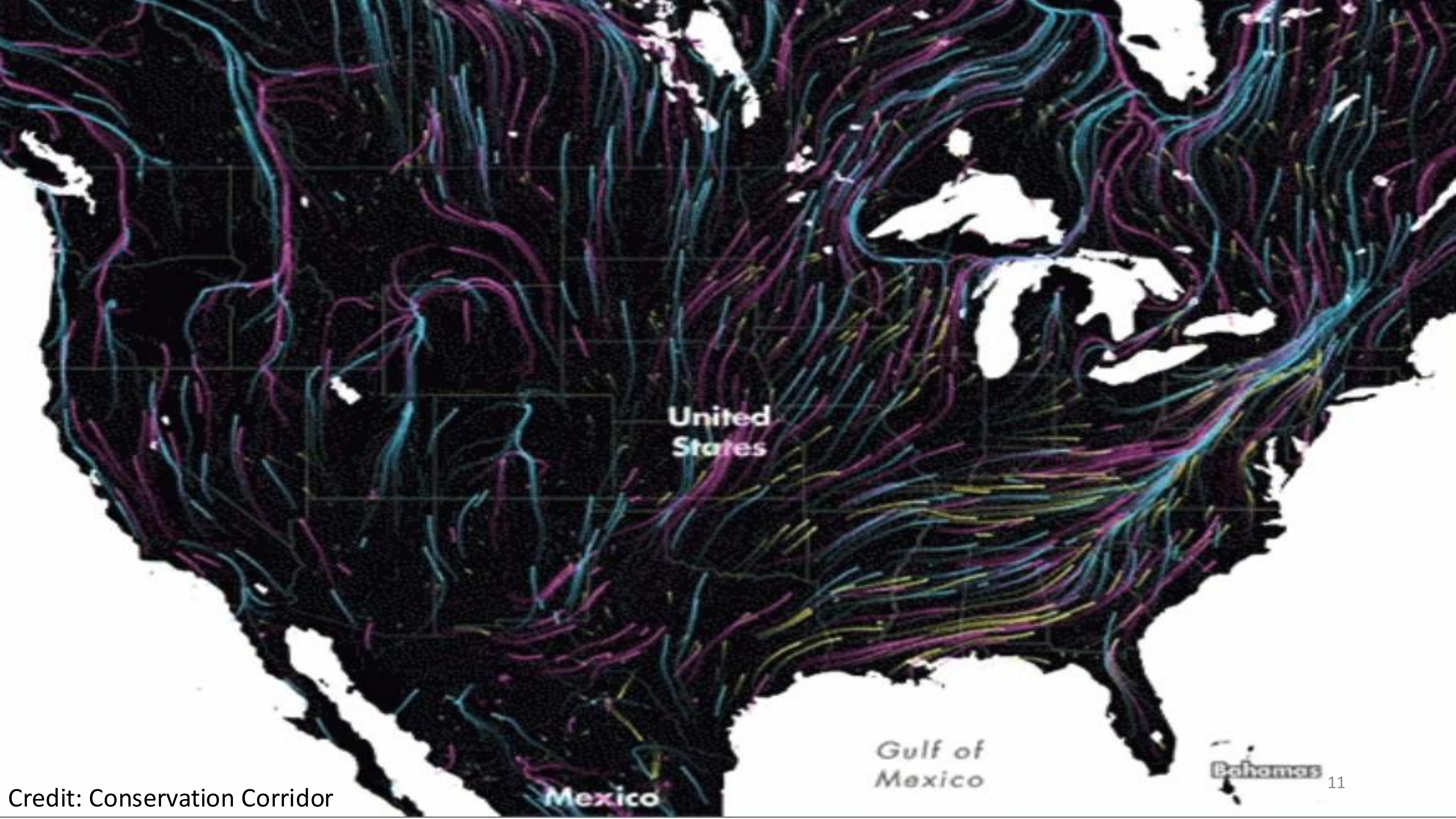
- Increasing temperatures can alter the climate of a given region

- Vineyard pests will likely move as their preferred climate migrates to new regions

- Most often, they may move North and toward coastlines

2. Wolfe et al. 2008.

3. Ameden and Just. 2001.



Credit: Conservation Corridor

Overwintering Success

- Winter is the farmer's friend
- Many insect, fungal, and bacterial pest populations are severely reduced during cold, wet winters
- Overwinter die-off helps limit starting populations of pests in spring
- Greater overwintering success with warmer winter temperatures
  - +2 ºF in CA since 1970s [4]

4. Tapan B Pathak et al. 2018.

Xylella fastidiosa – Pierce's Disease

Present in California for at least 200 years

19th century

- Wiped out grapes in S. California

1960s-80s

- Nearly wiped-out Temecula Viticulture

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Xylella fastidiosa – Pierce's Disease

- Negative impacts historically limited to hotter and drier S. California for hundreds of years
- With increased average temperatures we are starting to see impacts elsewhere
- Was already present, but would be 'killed off' each winter by the cold temperatures

Xylella fastidiosa - Cold Tolerant

- Overwinter recovery from Pierce's Disease relies on cold Winter temperatures < 53 ºF for prolonged periods [5]

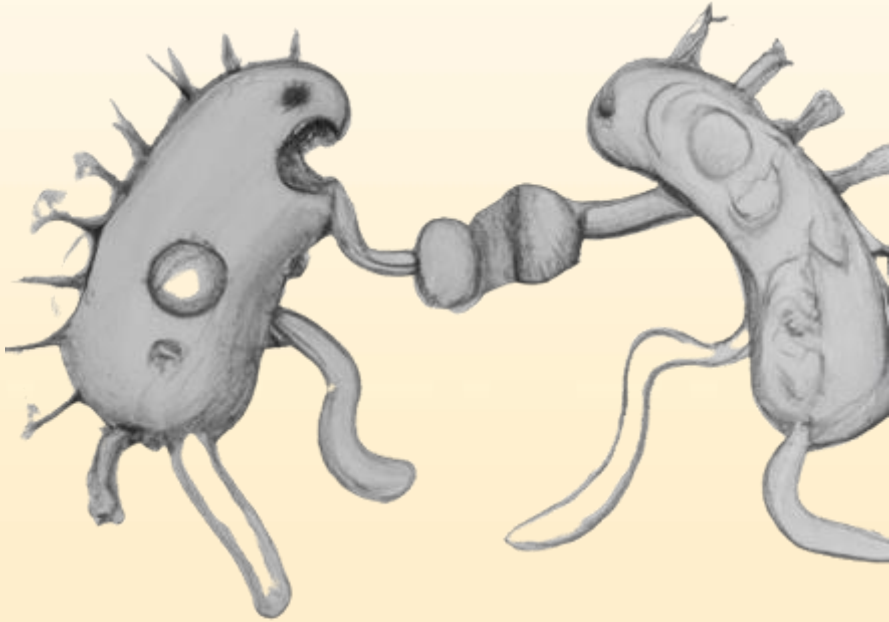
- Warmer winter temperatures could impede the phenomenon of overwinter recovery

- "New" strain of *X. fastidiosa* that is cold tolerant persists in Hopland, CA
  - Will S. CA variety be more able to survive winter as temperatures warm?
  - Will it be outcompeted by S. CA variety?

5. Feil and Purcell. 2001.

Bacterial adaptation

- Bacteria can also adapt to new conditions relatively quickly [6]
  - Quick generations
  - Plenty of genetic mutations
  - Gain OR loss of function
- However, there are plenty of bacterial species present in our environment that are already adapted to hotter and drier conditions
- This might result in a shift in localized-species composition if competing bacteria exist in the same niche



6. Hottes et al.. 2013.

Biotic x Abiotic Combined Stressors

- Water stress has been shown to increase transmission of *Xylella fastidiosa* in grapevines (7)
- Combined biotic and abiotic stress responses in plants often involve numerous signaling pathways
- Plants can tailor their response to specific stress combinations through hormone signaling, receptors, and transcription factors (8)

7. Del Cid et al. 2018.
8. Venkategowda et al., 2015.

Stressors in Vineyards

Abiotic stressors

- Frost damage
- Heat
- Drought

Biotic stressors

- Animal Pests
- Plant Pests (weeds)
- Diseases

Vine Stress Tolerance ~ available resources + (abiotic stress) + (biotic stress)

Main Factors – Emerging Pests & Diseases

1. Changing Climates
   - Winter temperature increases
   - Average temperature increases
   - Changes in precipitation
2. Species Rate of Adaptation
   - Speed of generational cycles
   - Rate of mutations in offspring
   - Varies by organism
   - Usually faster for microbes than macro-organisms
3. Movement of Pests/Diseases
   - Moving North in CA
   - Preferred climates across new geographic areas
4. Grapevine Susceptibility
   - Vines are not often adapted to handle impacts of pests they did not evolve with
   - Grape Phylloxera in *V. vinifera* vs. American rootstocks
   - Combined biotic & abiotic stressors

Changes in Existing
Pests & Diseases in Vineyards

Esca and Eutypa

- Long-term fungal trunk pathogens
  - May take 7-10 years to show symptoms
- Also influenced by climate conditions
- Symptoms may not be apparent until conditions are better for sporulation
- Host-Pathogen interaction is broadly impacted by environmental conditions
- Certain abiotic stressors can increase susceptibility of grapevines to pathogens or trigger symptomatic expression of the pathogen [9]

9. Fernandez et al., 2019

Phomopsis

- Has been reported to me frequently since 2023
- Preferred Conditions
  - High precipitation
  - Humid, canopy microclimates
  - Limited sun exposure
- North Coast vineyards are ideal habitat if weather conditions are right
  - “Cold-Climate” viticulture
  - Higher precipitation than many winegrape growing regions of CA
  - Many “shaded” canopies (sprawling canopy, shade or bird netting)

GRBaV & GLRaV

- Changes may be mostly via vector ~ climate interactions

- Confirmed Vectors
  1. Three-Cornered Alfalfa Hopper
  2. Mealybugs

- Treatment to remove virus involves rogue & replacing vines

- Make sure conditions on site are still good for vine establishment with chosen rootstock ~ scion

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Glassy-Winged Sharpshooters

- Vector of *X. fastidiosa*

- Compared to BGSS
  1. Larger populations
  2. Greater mobility
  3. Wider tissue range for feeding

- Temperature "Limits"
  1. Don't like to fly ≤ 65 °F [10]
  2. Don't feed ≤ 50 °F [10]

9. CDFA.CA.gov

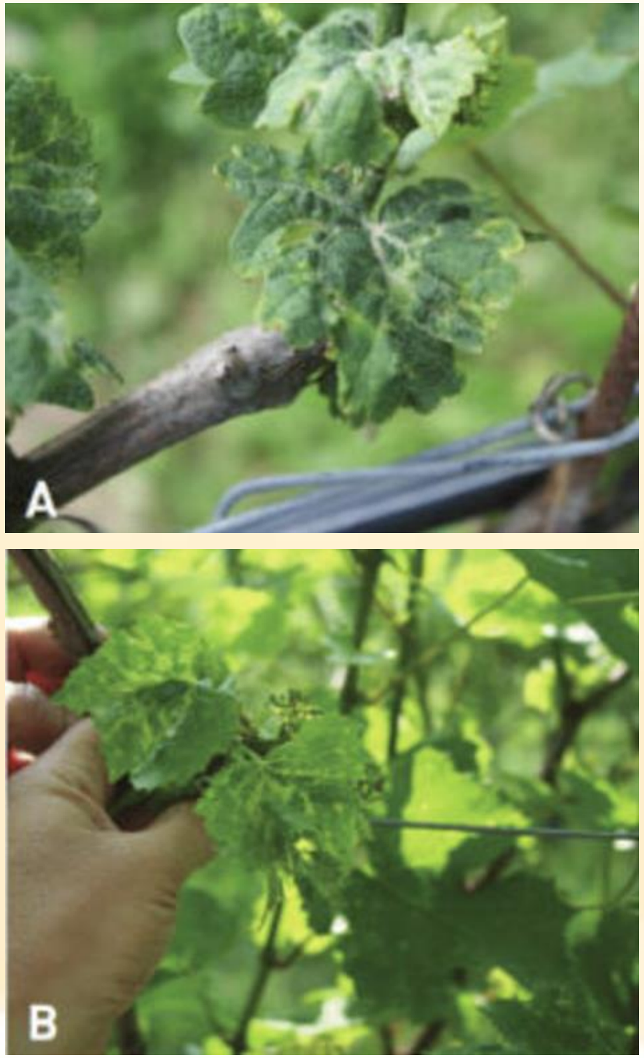
Vine Mealybugs

- Produce more honeydew than other mealybugs
- Changing climates could increase growth, reproduction, and range
- May also impact the symbiotic relationship with ants
- Good to monitor for mealybugs regularly and in areas they may not have previously been found

Emerging Pests & Diseases in Vineyards

Pinot Gris Virus (GPGV)

- First identified in Italy (2012)
  - Not found outside of Napa Valley in CA (yet)
  - Genus = Trichovirus
- Symptoms
  - Leaf deformation/discoloration
  - Delayed budbreak
  - Stunted shoot growth
  - Poor fruit set
- Infection via
  - Eriophyid mites
  - Vegetative material



Pinot Gris Virus foliar symptoms (Agriculture Victoria. 2020)

Petri Disease, Black Goo, & Blackfoot Fungi

- More common in vineyards prone to flooding
- *Phaeomoniella* genus
  - (several species)
- Affects the vascular system
- Symptoms
  - Shallow or reduced root mass
  - Small trunks in mature vines
  - Uneven shoot lignification
  - Wilted leaves or entire shoots

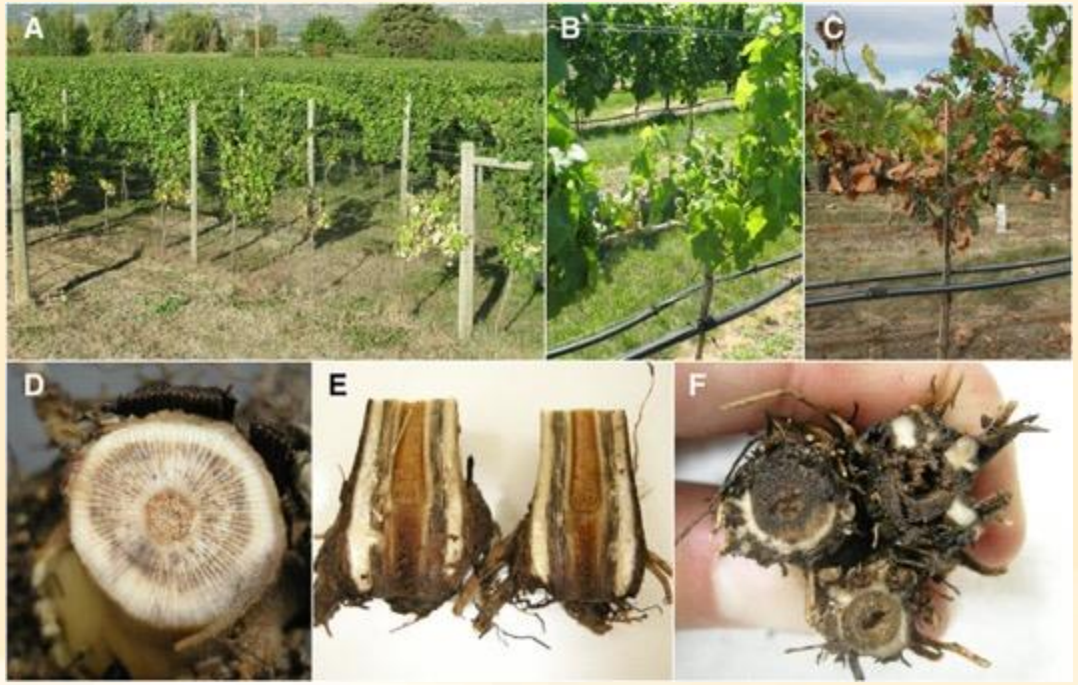


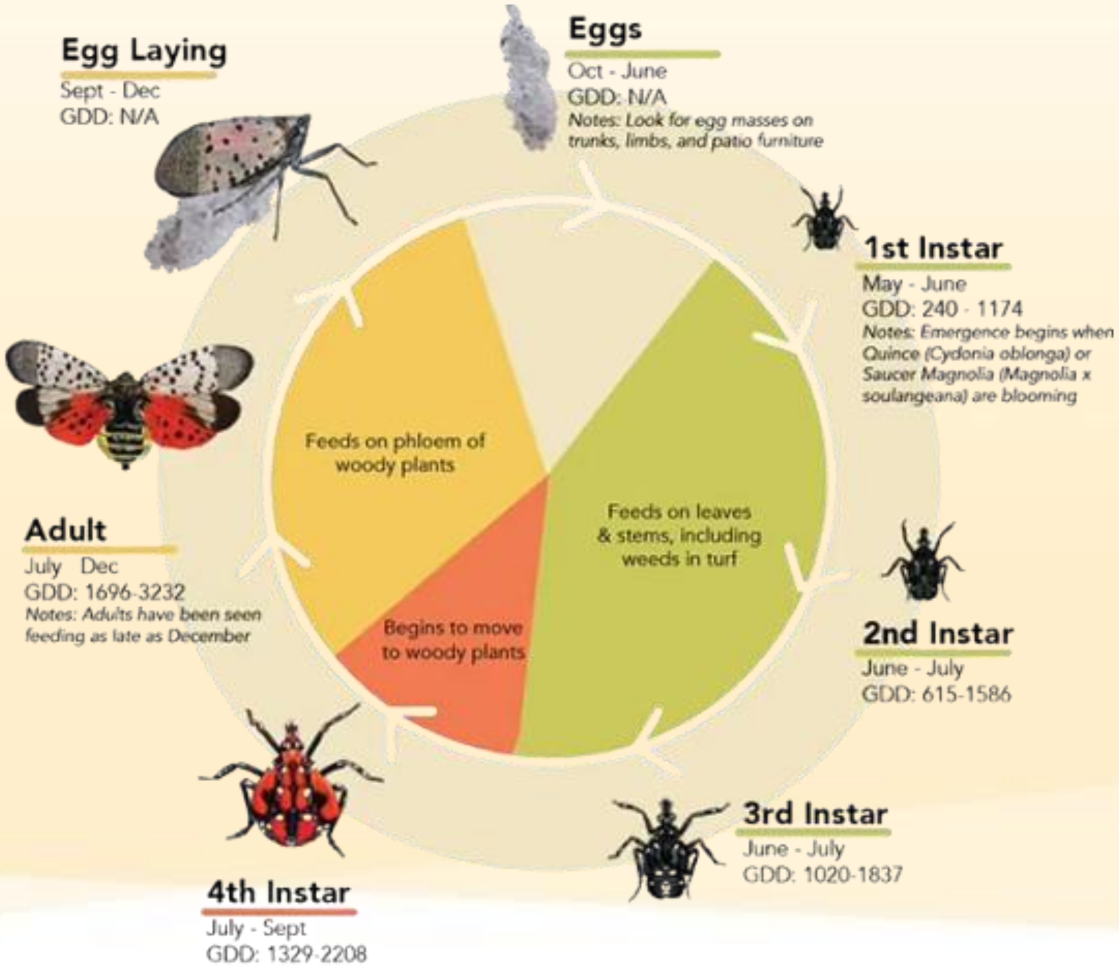
Figure 2: Gramaje et al., 2018

11. Gramaje et al., 2018

Emerging Insect Pests

Spotted Lanternfly

- Over 100 host species
  - Tree-of-Heaven (preferred host)
  - TOH is not required to complete lifecycle
- May have additional host plants in CA that are not grown in regions with existing infestations
- Lays eggs in rows on almost any flat surface (inanimate too)
- One generation per year
  - Not confirmed in California (warmer)
- Excretes a lot of honeydew
  - Promotes Sooty Mold

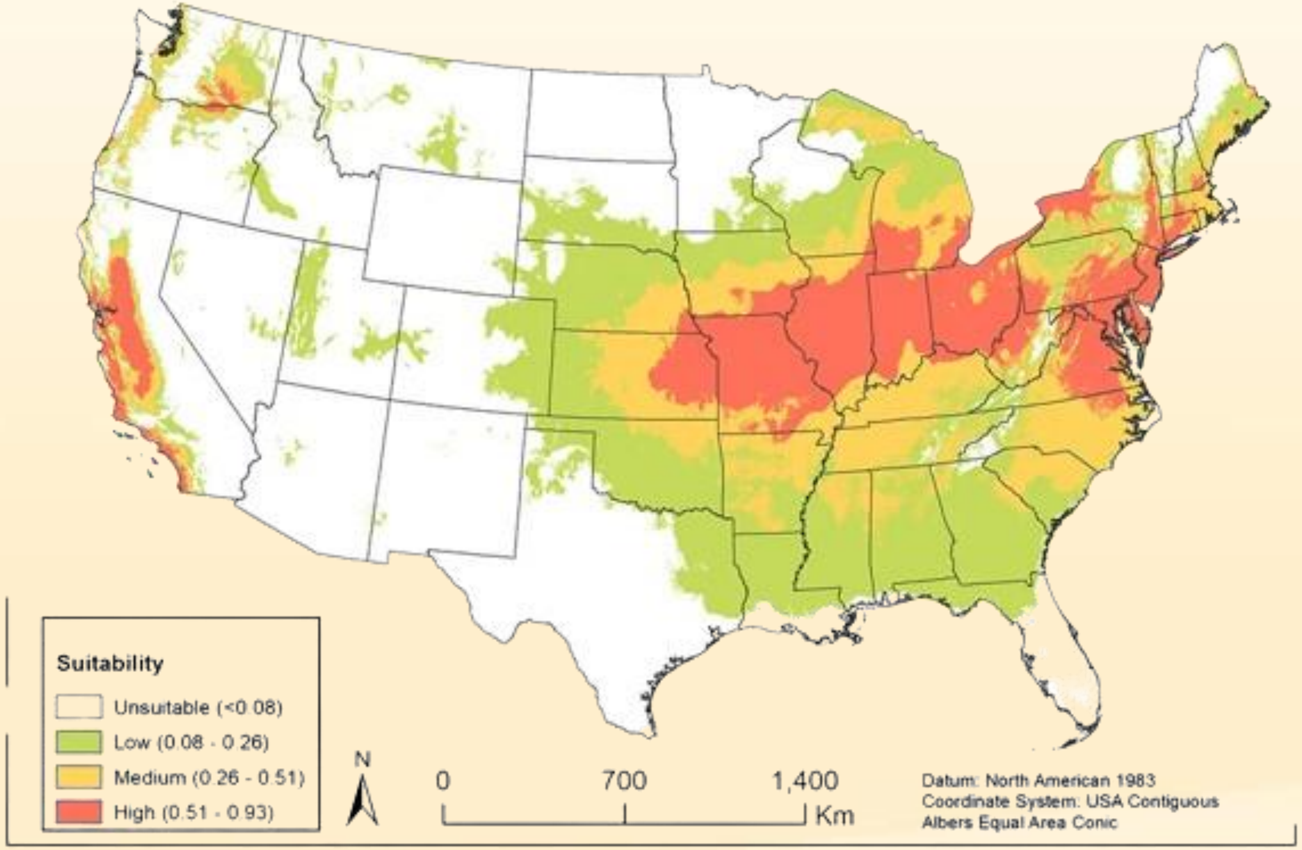


Credit: Rainbow Ecoscience

Spotted Lanternfly

- Currently in at least 20 states
  - Verified sightings
  - Mostly East Coast and Midwest
- CA quarantine est. in 2021
- Can reach populations high enough to kill whole vineyards
- Train others to be able to identify SLF at later instars
- Please report to Agricultural Commissioner's office if found

Potential distribution of SLF in USA



EntomologyToday.org

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European Grapevine Moth

- Timeline
  - 2009 = Found in Napa Valley
  - 2016 = Eradication Declared
  - 2024 = Monitoring Ongoing
- Eggs often laid in small clusters on grape flowers, berries, or leaves
- Larvae feed on grape berries
  - Allow for 2º fungal infection
- Not "emerging" but good to keep in mind

Light Brown Apple Moth

- First detected in CA in 2007
- Invasive and under quarantine
- Eggs laid in clusters on leaves/stems
- Damage
  - Larvae feed on leaves, flowers, & fruit
  - Create webbing on leaves (may roll)
  - Feeding wounds prone to 2º infection
- Over 200 known host plants
  - Grapes not preferred host but LBAM will feed on grapevines if populations are high enough

Mediterranean Fruit Fly

- Does not typically impact grapes, but can feed on berries if conditions are favorable and other hosts are not available
- Thin-skinned grape varieties (Table grapes) are at higher risk
- Higher risk of contamination, spoilage, and 2º fungal infection than direct feeding damage in grapes

Brown Marmorated Stinkbug

- Invasive pest introduced in late 1990s
- Overwinter in sheltered areas
- Piercing-sucking mouthparts
- Feeding damage on fruit can lead to discoloration and berry skin cracking
- Can contaminate wine with the strong smell they release when crushed
    - Adds an "herbal" aroma

Mediterranean Oak Borers

- Does not directly impact grapevines
- Can increase risk of fungal infection in Oak trees
- Can indirectly increase risk of fungal infection in grapevines
- An important pest for vineyards when viewed as a **whole system**

Pacific Flatheaded Borer

- Recently found larvae feeding **on fruit**
  - This is a new behavior
  - Concerning to pear producers
- Found mostly in Organic Pear Orchards in Lake County
- Too early and too sparse to know much else

Emerging Weeds

Herbicide Resistance

- Perpetual problem in weed management
  - 1957 (Hawaii): 2,4-D resistance in Dayflower
  - **1960: Green Revolution**
  - 1960 (Kansas): 2,4-D resistance in Bindweed
  - 1981 (California): First case in CA (UC reported)
- Still ongoing
- Rotating modes of action acts
- But we also have “emerging” weeds

Norman Borlaug - 1960

Poke Weed

- "Tuber-like" taproot that grows
- Tall plant (6-10 ft tall)
- Often found in disturbed areas
    - Fence lines
    - Block edges
- Damage / Issues
    - All parts of plant are poisonous
    - Toxic to animals & humans
    - Spread by birds

Hairy Fleabane

- Glyphosate resistance reported
- Summer, annual weed
- Grows vigorously
- Can outcompete grapevines for water and nutrients
- Can interfere with vineyard machinery

Goosegrass

- Summer, annual bunch grass
- Originally, not a huge problem
  - Very adaptable
  - Would be difficult to control by hand management
- Can be controlled with both pre- and post-emergent herbicides
- Becoming difficult to control (suspected glyphosate resistance)

Penn State Extension

Witchgrass

- Witchgrass reported resistance to Atrizine
  - If Atrizine is used, Witchgrass can take over large areas of the vineyard floor following loss other ground cover

- Otherwise, very manageable

Witchgrass (Penn State Ext)

Stinkwort

- 1984 – First reported in CA
- Spread rapidly since then
- Not palatable for grazing animals
    - Can cause skin irritation in humans too
- Excrete an organic oil that has been compared to Vick's Vapor Rub
    - Reported to influence the taste of grapes

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Purple Loosestrife

- Wetland herb-weed
- Disturbs soil-water flow
- Degrades wetland habitats
- Can be found along waterways
- Can outcompete native riparian species

Reported populations
(Cal-IPC.org)

Horseweed (Mares Tail)

- Common weed in SJV/ C. Coast
  - 200,000 seeds/plant
  - Seeds can distribute with wind
- Can germinates year-round
  - As long as water is available
- Water hog and large plant
  - 6-8 ft tall
- Glyphosate resistance reported

University of Wisconsin

Star Thistle

- Nuisance for humans and livestock
  - Stabby – Pokey bits
- Grow in dense populations
  - Can limit vineyard accessibility
- Toxic to horses but not other livestock
- Produces lots of seeds
  - Viable for up to 3 years

Giant Reed (*Arundo donax*)

- I very much dislike this plant
- Native to Western Asia
  - Introduced for erosion control in 19th century
- Seeds are nonviable outside of its native range
  - Still highly invasive in CA
  - Only reproducing clonally
- Riparian areas preferred
  - Can produce clones from any bit of tissue with access to water

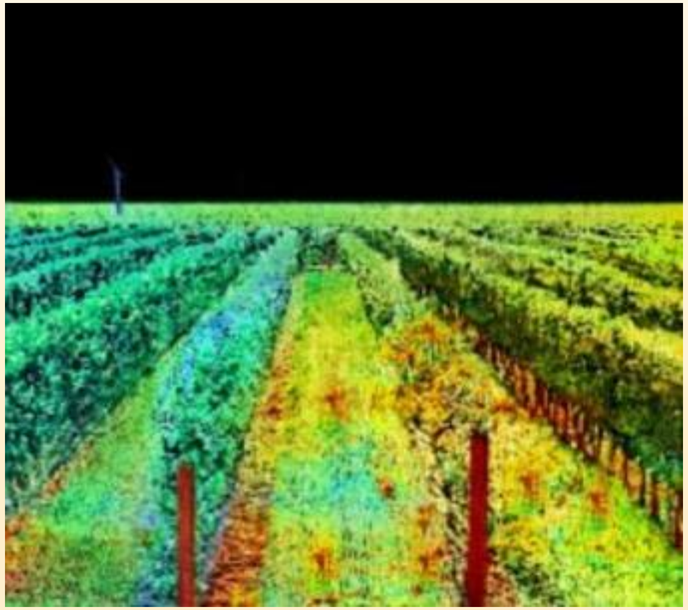

Tree-of-Heaven (*Ailanthus altissima*)

- Preferred host of Spotted Lanternfly
- Reproduces in multiple ways
  - By seed (like other plants)
  - Rhizomatous (oh no!)
- First introduced to CA during 19th century Gold Rush
- Really difficult to eliminate
  - Females should take priority (produce seeds and reproduce via runners)
  - Requires Autumn removal with stump-painted herbicide or herbicide injection
  - Must be done over multiple years

Emerging Strategies to Mitigate Pests/Diseases

LiDAR – to improve IPM efficiency

- LiDAR (Light Detection and Ranging) is now being used for multiple pest control methods in vineyards
- Identification of flying insect pests
  - Uses LiDAR to identify flying insects in vineyards using the frequency and patterns of their wingbeats
  - Accurate up to 120 m
- Reducing chemical application rates in canopies
  - Use LiDAR to identify canopy density
  - Variably adjust chemical application rate to match density of the canopy being sprayed (**Precision Variable Rates**)
  - Wine Australia* decreased effective pesticide spray volumes required in sparse canopies by 50-90%



Source: Iridesense

* Wine Australia – LiDAR research

Eavesdropper

- Dr. Emily Bick – University of Wisconsin-Madison
- Device uses machine learning and a detection sensor to listen to and identify feeding of insects on the roots of plants
- Can use this to identify the pest
  - 80 – 96% accurate
- Cindy Kron is testing this on grapevine pests in N. CA

Dr. Emily Bick with Eavesdropper device

Artificial Intelligence for Pest Management

- Hardware like LiDAR and Eavesdropper acquire a lot of data when deployed
- Software or AI is necessary to reduce the noise produced by outliers and errant data points [11]
- Machine and Deep Learning algorithms will improve the range of what is possible with these new sensors and novel hardware being developed

Source: ChatGPT4 (Microsoft CoPilot)
Prompt: "Make an image of ChatGPT as a human examining a moth"

11. Kariyanna and Sowjanya. 2024.

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Resources & Training Tools

- Pinned insect Samples - https://bioquipbugs.com/
- Drone Camp - https://dronecampca.org/
- AI Institute for Next Generation Food Systems - https://aifs.ucdavis.edu/
- University of California IPM resources - https://ipm.ucanr.edu/#gsc.tab=0

Sources

You can find this presentation at:

1. https://ucanr.edu/sites/chenlab
2. Speaker Presentations

Some original images created by OpenAI Labs / Microsoft CoPilot

Thank You