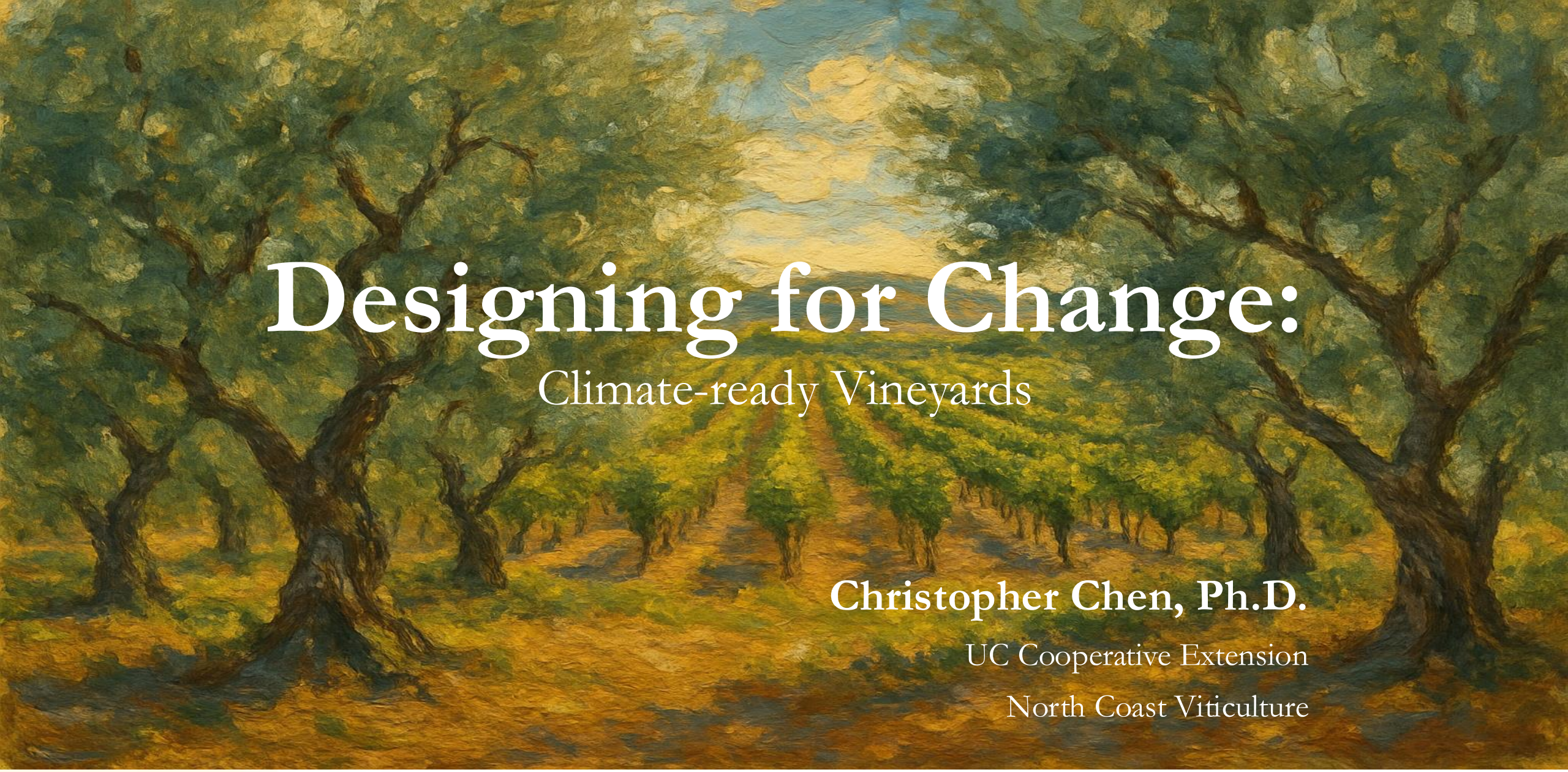

Designing for Change:

Climate-ready Vineyards

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UC Cooperative Extension

North Coast Viticulture

Climate Concerns

- Global average temperatures have risen by at least 3 °F since the start of the 20th century
- Drought persists in the West Coast
- Extreme weather events have become more frequent
    1. Large wildfires
    2. Prolonged heatwaves
    3. Unexpected freeze events
    4. Drought or excessive precipitation

Climate Impacts

Must consider both **direct** and **indirect** impacts of changing climates

1. Change in growing season length
2. Earlier or later budbreak and ripening
3. Resource scarcity (i.e., water/fertilizer)
4. Increased soil salinity
5. More extreme weather events
6. Changes in pest development and behavior








66.6
°F/°C

Climate Concerns with Agriculture

- Climate conditions impact many aspects of agriculture

    1. Resource availability
    2. Extreme and sudden weather events
    3. Biotic and Abiotic stressors
    4. Pest/disease success and survival
    5. Phenological timing of crops
    6. Yields
    7. Plant health

Vine Health ~ Vine Abiotic Stress

- In grapevines, abiotic stress can be persistent or additive with other stressors
- Plants do not have an immune system
  - Additive resistance
  - Defense compound synthesis
  - Abiotic stressors redirect resources
- Can tolerate many stressors, but there are limits to what a vine can handle

Vine health ~ available resources - (abiotic stress) - (biotic stress)

Vineyard Health

- 'Health' – the state of being **free** from illness or injury
- No way to be **totally free** of health-limiting factors
- The next best option is to look for preventative options

Vineyard Design for Climate Adaptation

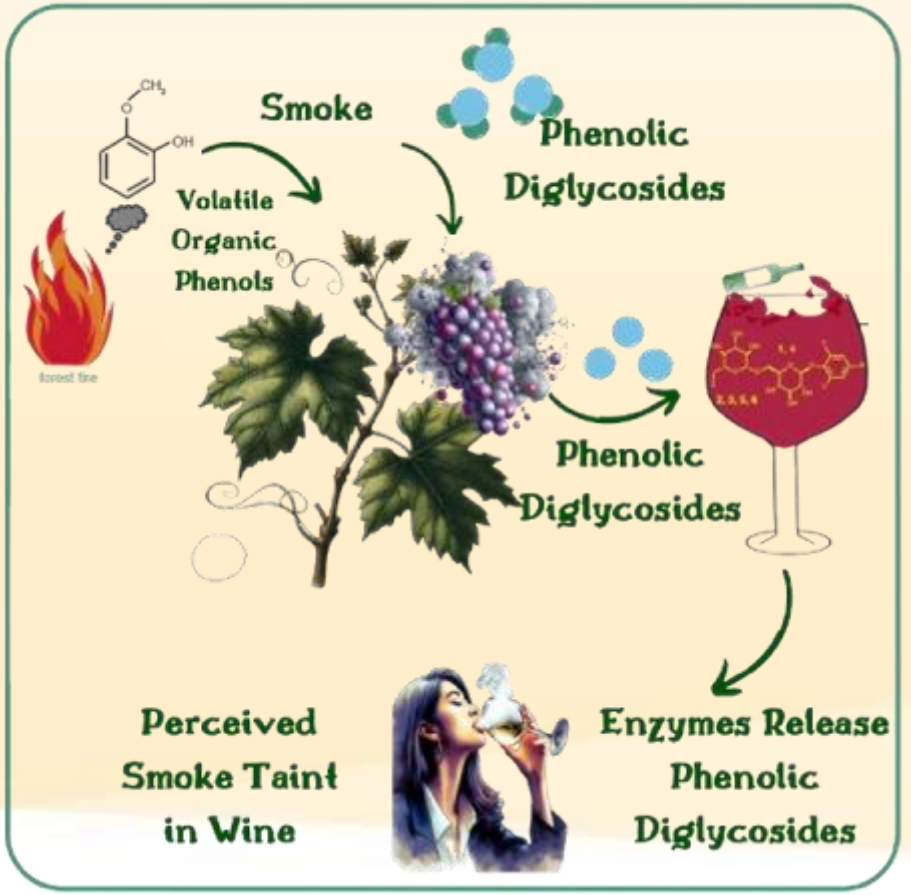
Major Viticultural Challenges from Climate Change

1. **Temperatures**
   Heat degradation and canopy damage
2. **Overexposure**
   Too much direct sunlight
3. **Pests & Diseases**
   Also are acclimating to changing conditions
4. **Resource Availability & Quality**
   Water in particular
5. **Fire & Smoke**
   Cause both direct and indirect damages
6. **Labor & Ease of Management**
   Indirect but impactful challenges with implementation of practices

Smoke Taint and Fire Damage

Risk levels of smoke taint from wildfire impacts are modified by many factors:

1. **Fuel Source**
   Different source materials release different volatiles
2. **Distance form source**
   Closer fires carry more VOCs in suspension
3. **Vine phenology**
   Fruit with higher sugars at higher risk
4. **Natural barriers**
   Foliage can sequester airborne VOCs before vines
5. **Age of smoke**
   The "fresher" the smoke, the more risk of smoke taint



Foliar Barriers

Proper forest management can reduce the risk of smoke damage

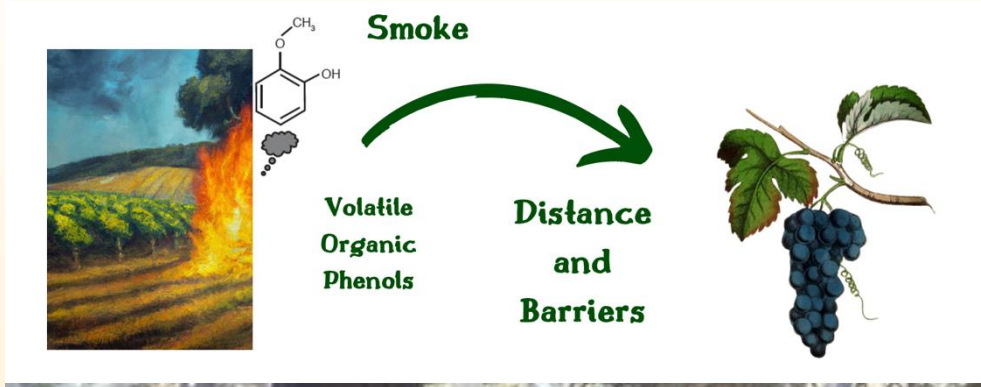
If you have forests on your property, try to:

- Reduce fuel loads on the forest floor
- Remove dead and dying trees
- Keep a solid canopy and understory shrubs

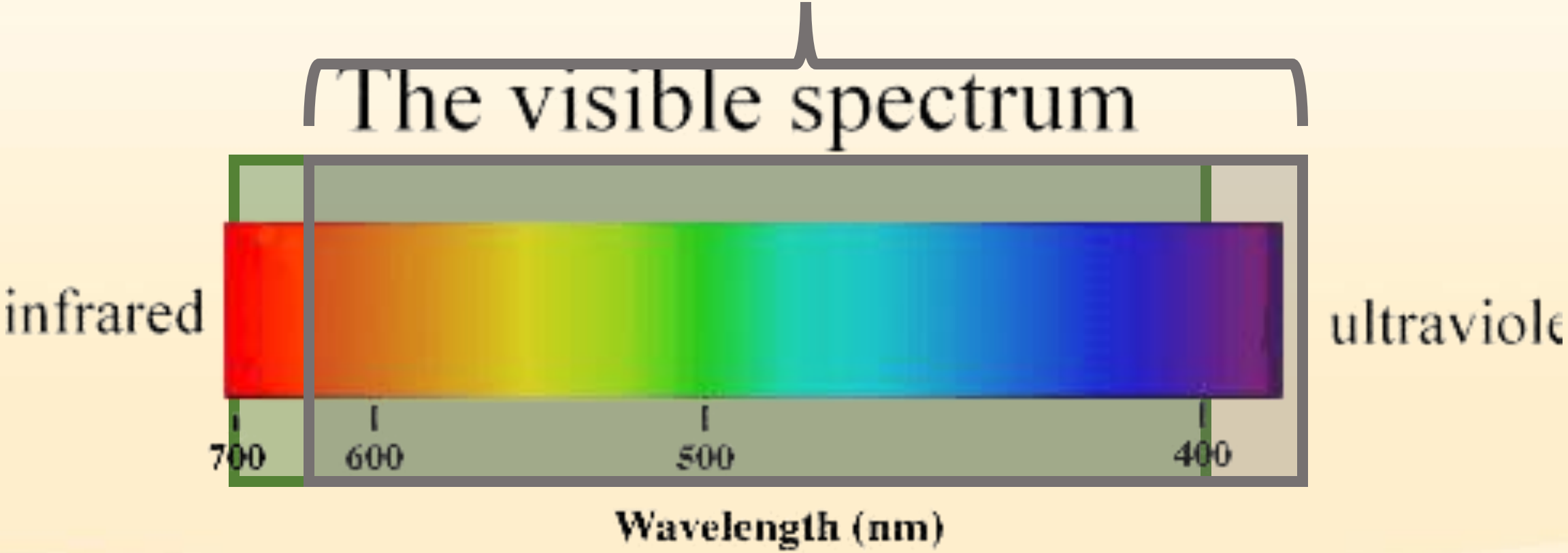
Like grapevines, other plants can bind volatile phenols

Larger (weeping) grape canopies and natural foliage can be used as a 'smoke-break' and bind the volatile phenols before they reach your grapes

This is an example of a long-term solution to a climate-change fueled problem



Wavelengths reduced from wildfire smoke



Photosynthesis

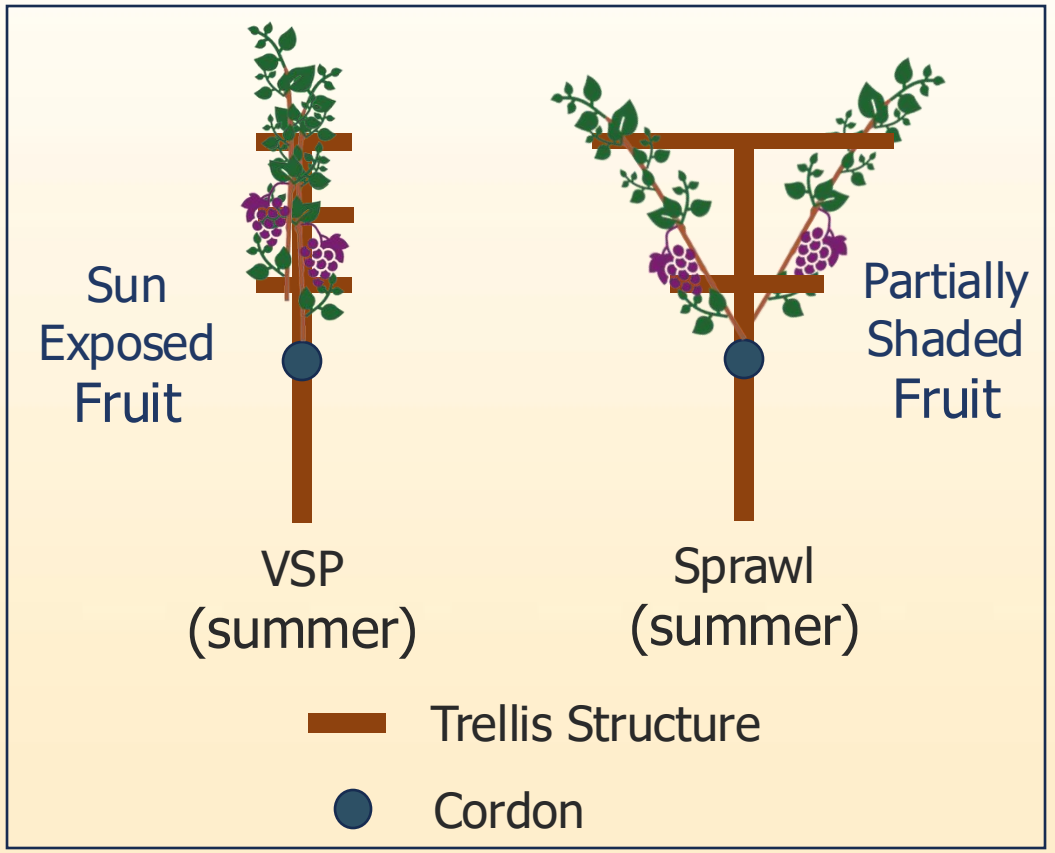
Heat and Sun Exposure

- Can result in rapid degradation of fruit phenolic compounds
- Can also result in direct damage to fruit (i.e., shrivel and Raisining)
- Stomata can close in response and reduce gas exchange
    - Effects photosynthesis and respiration

Cultural Solutions

Long term solutions

- **Trellis design**
  - Sprawling canopies offer self-shading
    e.g., CA Sprawl, T-Top, or Wye trellises
- **Cultivar Selection**
  - Some cultivars perform better in heat
    e.g., varieties from the Mediterranean shores



Short term responses

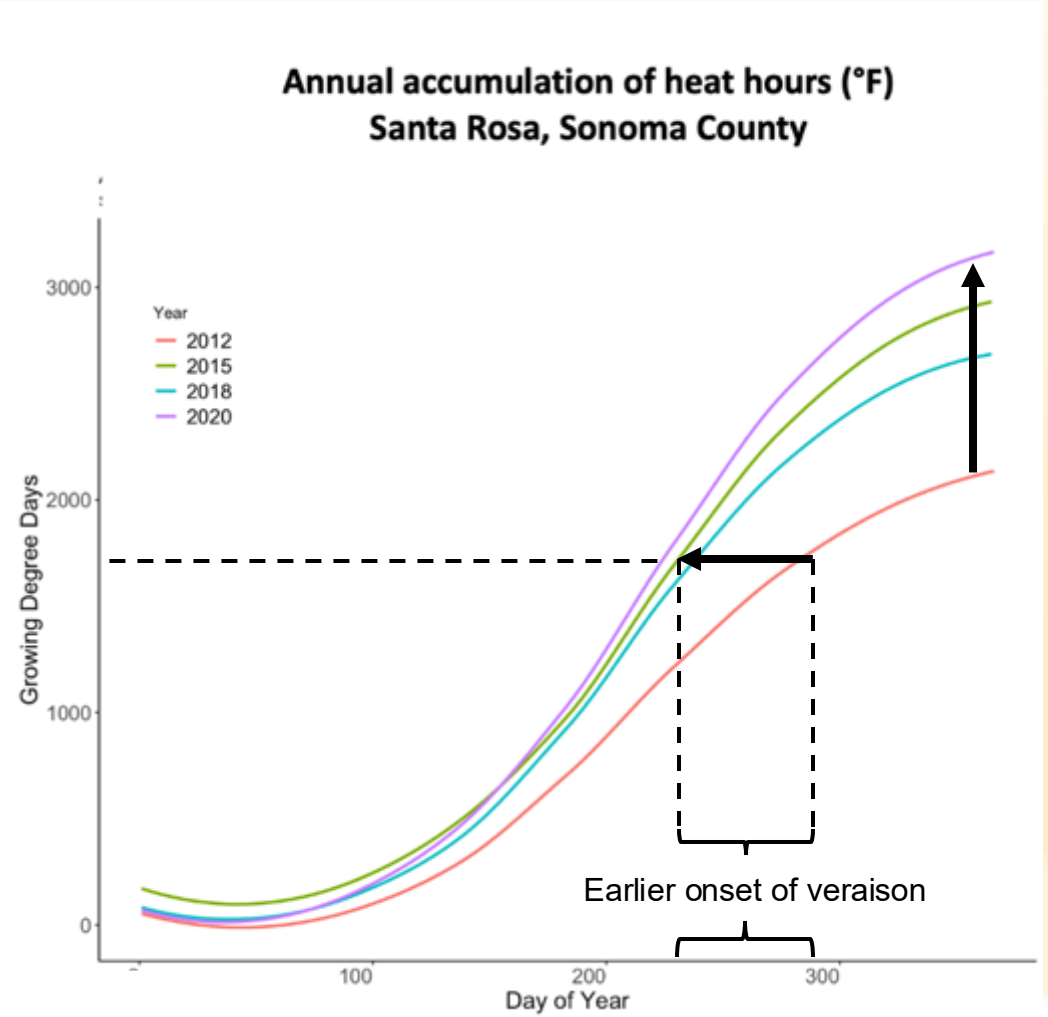
- **Irrigation Response**
  - Irrigating at the start of a heatwave doesn't help much
  - Irrigating at the start of a heat wave can help keep stomata open during high heat stress
- **Shade Netting and other artificial means**
  - When existing infrastructure or canopies are insufficient they can be supplemented

Increasing Temperatures

In Central Europe the impact of warming climates has been documented in Bernáth et al. 2021

Between 1985 and 2018

- Budbreak: 5-7 days earlier
- Flowering: 7-10 days earlier
- Berry maturity: 18 days earlier
- Harvest: 8-10 days earlier



Cumulative heat accumulation in Santa Rosa, California in 2012, 2015, 2018, and 2020. (Data from https://cimis.water.ca.gov)

Pest Responses to Climate Change

Insects can respond to climate change in several ways; three major responses that have been cited are:

1. Moving to a climate more suitable to them
2. Shifting developmental timing (phenology)
3. Adapt to the new conditions and the associated impacts on the ecosystem (true evolution)

‘New’ diseases in vineyards

Often can be difficult to identify:

- Lime disease on the West Coast or GRBV in vineyards

Grapevine Red-Blotch Associated Viruses

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

Disease Expression

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

Example:

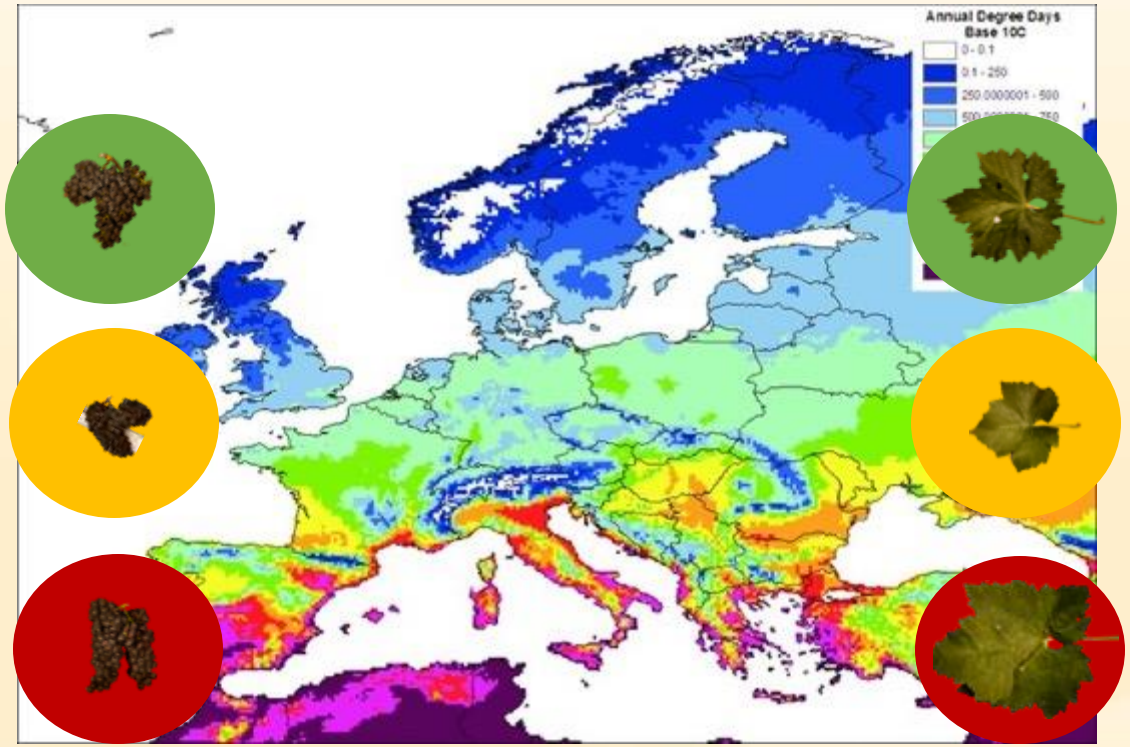
- *X. Fastidiosa* has been observed to spread and proliferate easier in drought stressed grapevines

Actions We Can Take

What to Pay Attention to

Climatic Origins

Where did the scions originate from?



This impacts their tolerance for heat (and other stressors)

- Hot climate – Heat and drought tolerance
- Cold climate – Frost aversion phenology

Think about how your climate matches up with the original climate of the scion

Short-Term Solutions Exist

- Many issues can be addressed in the short term with add-on solutions
- Shade netting can protect against sudden heatwaves or damage from drought + heat
- Other short-term products are available to address immediate risks
- These are not permanent solutions
- Can be expensive and require directed solutions for specific challenges

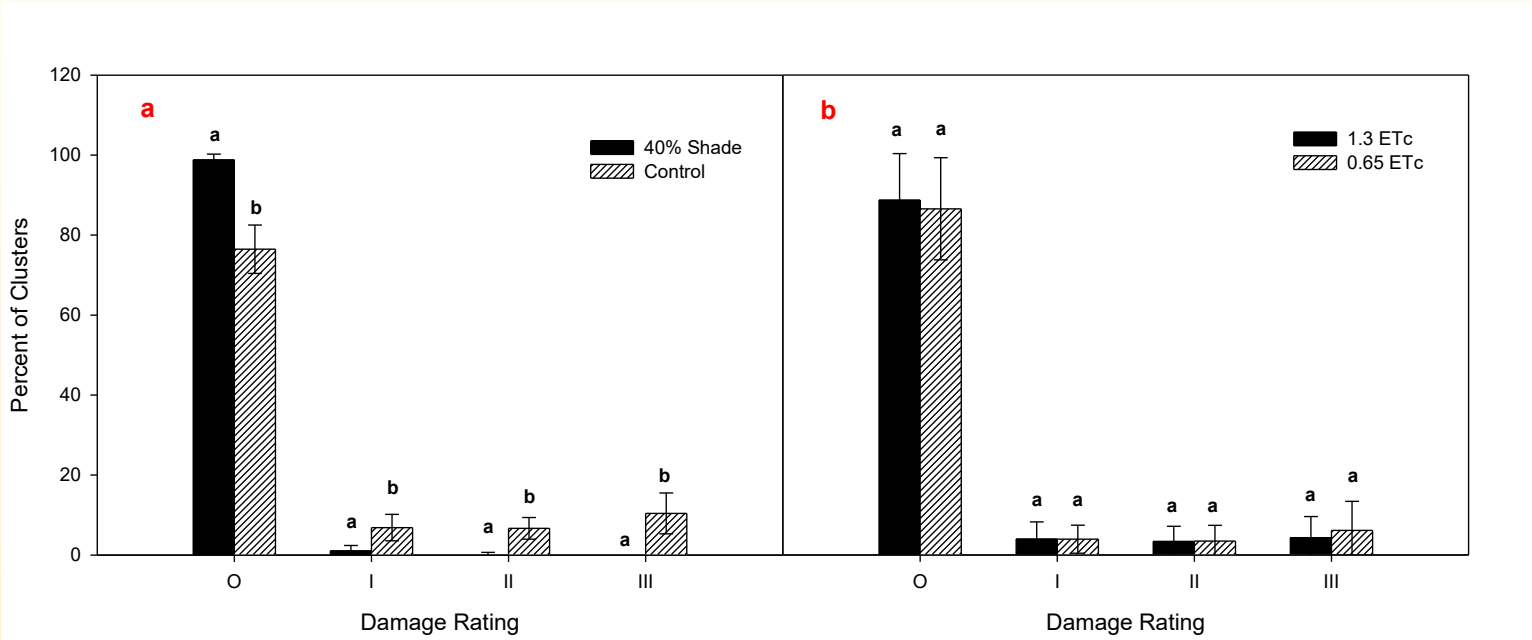
Shade net study – Oakville (2016-2017)

Light-modification study (2022)

Targeted Solutions

Using a rating system we visually assessed damage to whole clusters attributed to excess exposure:

- 0 = No damage
- 1 = Minor damage
- 2 = Moderate damage
- 3 = Extreme damage



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Long-Term Solutions

Long term solutions imply a practice that takes multiple years to achieve targeted results

These might include

- Forest management as smoke breaks
- Replacing inefficient systems
- Designing trellis to match extreme events

The longer the practice takes to yield results, the more difficult it is to justify

Often long-term solutions provide the most effective resolutions to issues

Monitoring

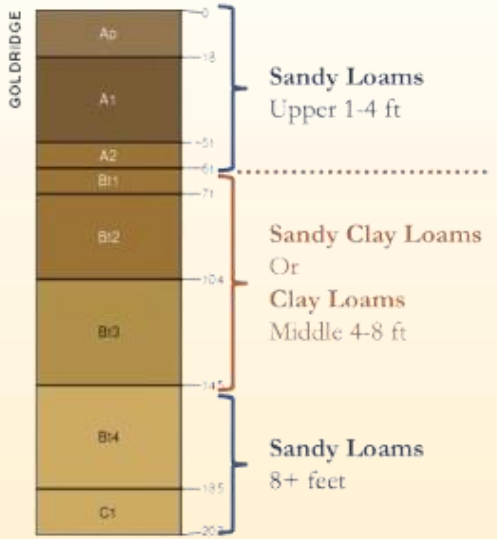
- Monitoring the state of your vineyard is the key to effective management decisions
- Monitoring vineyard pests and diseases may be more important now than in recent memory
- Allows for preventative actions which may be more cost effective than remedial ones
- Make use of what we know about vine responses to stress:
  - Measurements of vine physiological responses (i.e., stomatal conductance)

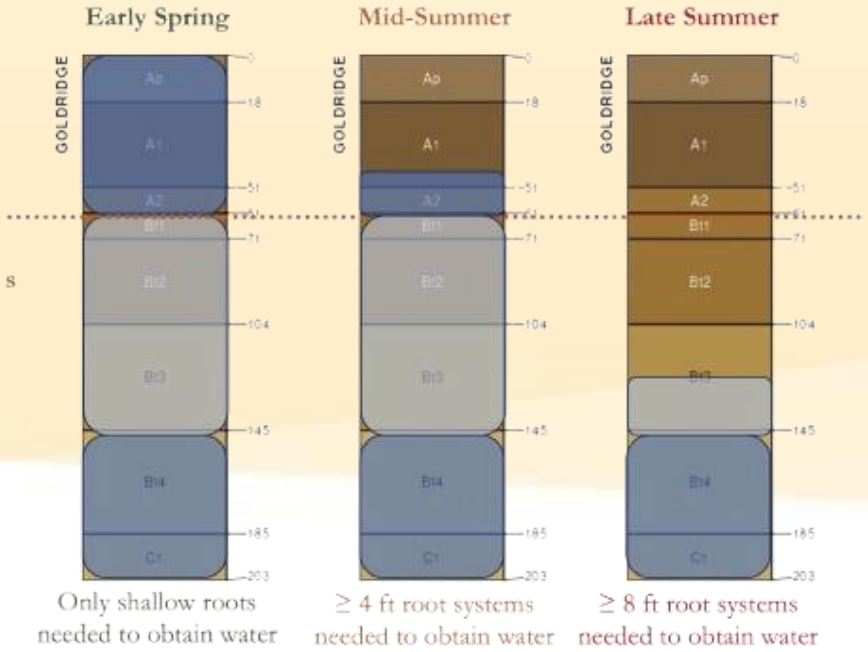
Resource Use Efficiency

Already shifted to low-input, highly targeted water application (i.e., drip systems)

How can we improve that further?

- Update irrigation infrastructure
- Monitor performance of irrigation systems
- Reassess our irrigation regime strategies
- Manage soil health for better
    i. Infiltration rates
    ii. Water holding capacity
- Design irrigation systems for:
    i. Less friction to reduce pressure losses
    ii. Easy repair and maintenance





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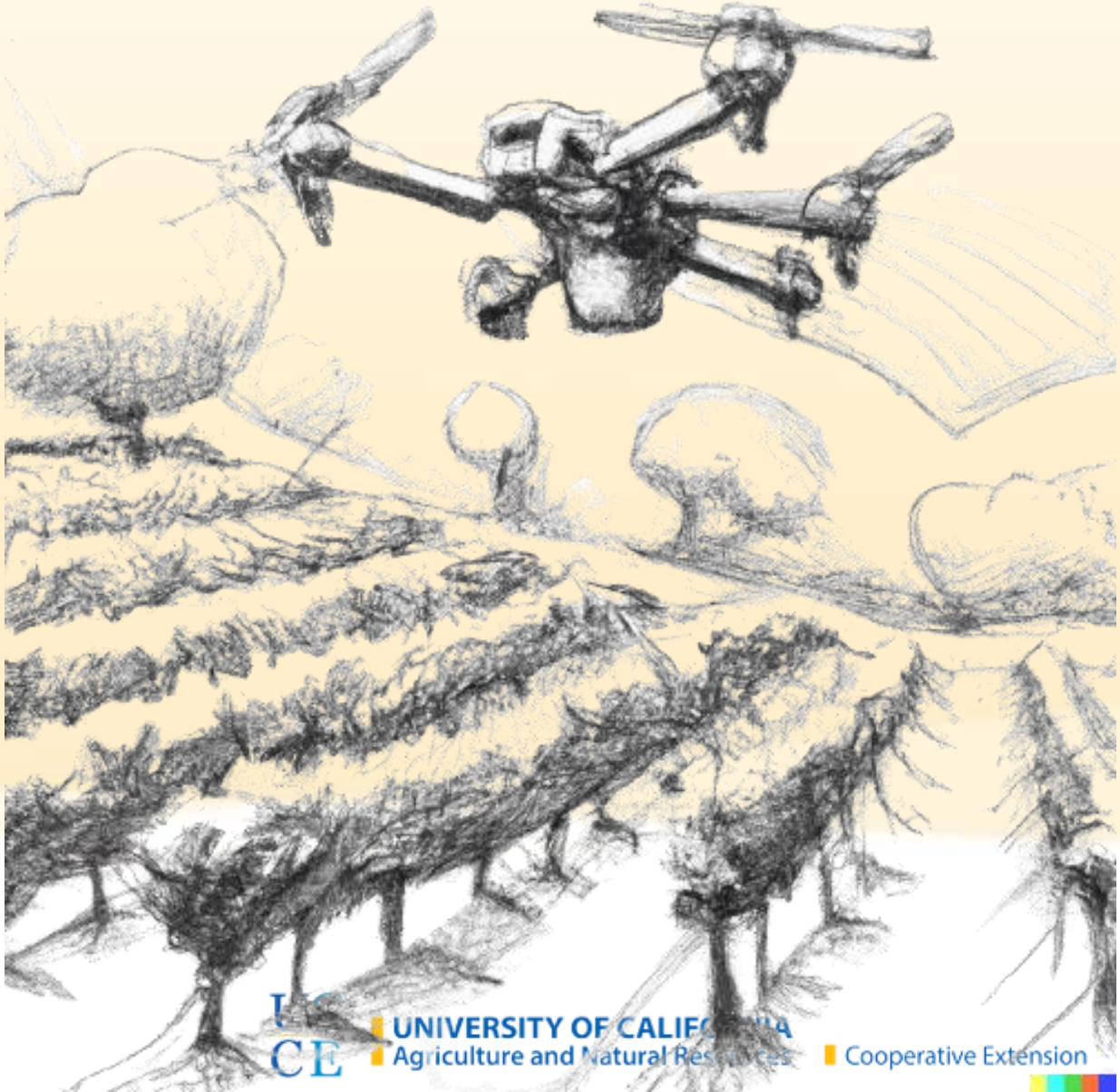
The Climate-Adaptive Vineyard

The Climate-Adaptive Vineyard

1. Water Use Efficiency
    - Drought tolerant cultivars
    - Precision irrigation methods
    - Water-efficient cultural practices
    - Better soil-water dynamics
2. Heat/Drought tolerant varieties
    - Research and testing
    - Available and adopted
3. Pest-tolerant rootstocks
    - Identify future pest risks
    - Research and testing
    - Available and adopted

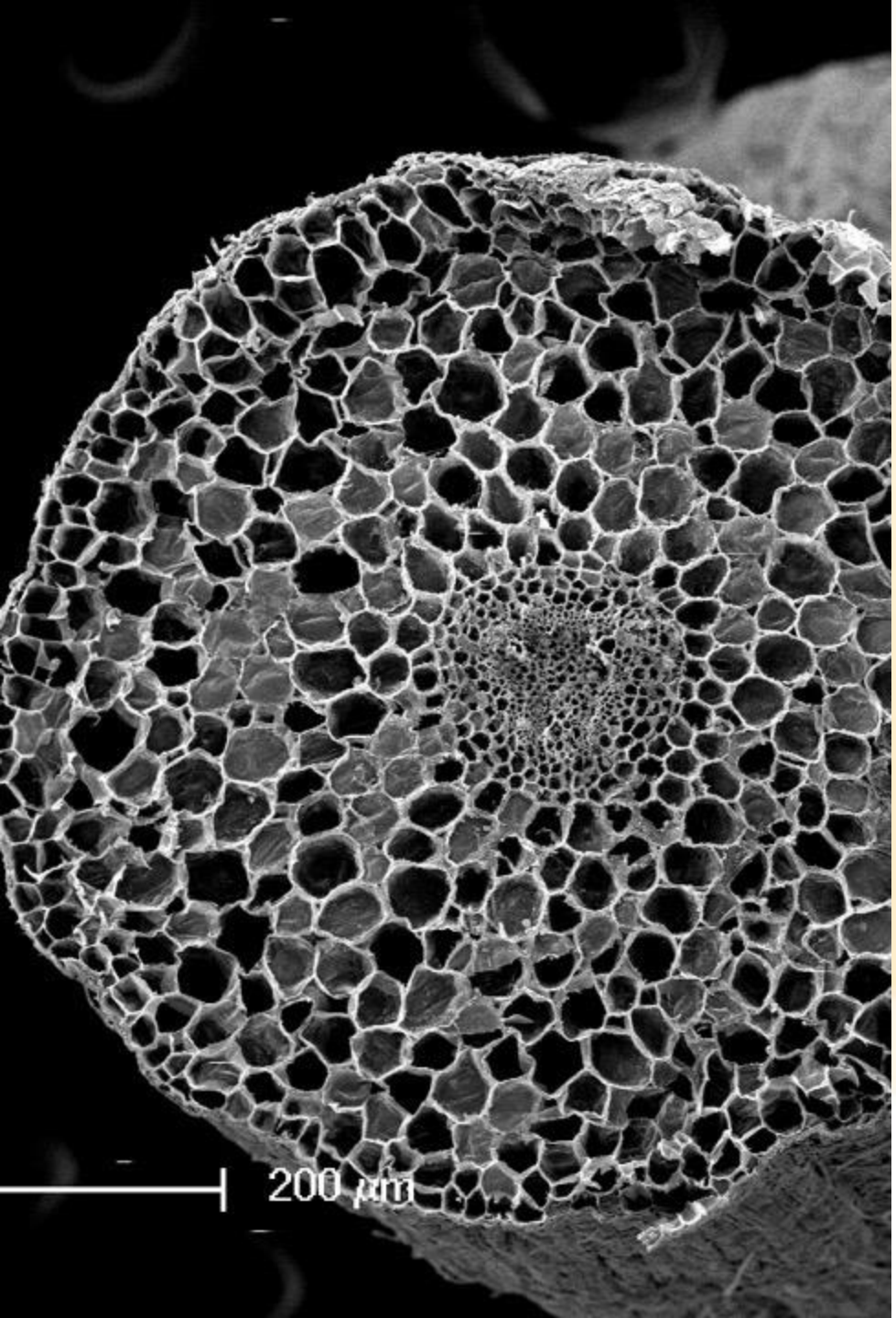


The Climate-Adaptive Vineyard

4. Efficient management practices
    - Precision irrigation
    - Optimize canopy design
5. Improving soil health
    - Increasing water infiltration
    - Improve water retention
    - Improve nutrient retention
    - Promote mycorrhizae health
6. Desirable employment
    - Make jobs desirable
    - Improve employee retention and well-being
    - Keep skilled-labor

The Climate-Adaptive Vineyard

7. Consistent monitoring
    - Look out for new issues
    - Observe and record patterns and trends
    - Get ahead of challenges before they become costly
8. Ready adoption of new practices
    - Growers willing to try out new concepts and practices
    - Increase our climate-resilience greatly



Summary

1. Climate change impacts all aspects of agriculture

2. Any stressor ties-up grapevine resources and limits its ability to defend against new stressors

3. Climate adaptive vineyards will be heavily impacted by resource use efficiency and effective management practices

4. Long-term solutions and short-term solutions exist to climate-related problems; decide which is better for you

5. Development and testing of alternate solutions to changing climate challenges is needed
   - -Resource allocation - Infrastructure designs
   - -Vine and soil health - Limiting controllable stress

Downloadable Presentation

- You can find this presentation at:
  1. https://ucanr.edu/sites/chenlab
  2. Speaker Presentations

Some original images created by OpenAI Labs Dall-E 3 Program and in https://BioRender.com

Thanks for Listening

Contact me: codchen@ucanr.edu

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