Smoke taint risk in winegrapes during prescribed burns

Preliminary Study at Hopland REC

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Vineyard Health

- ‘Health’ – the state of being **free** from illness or injury

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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

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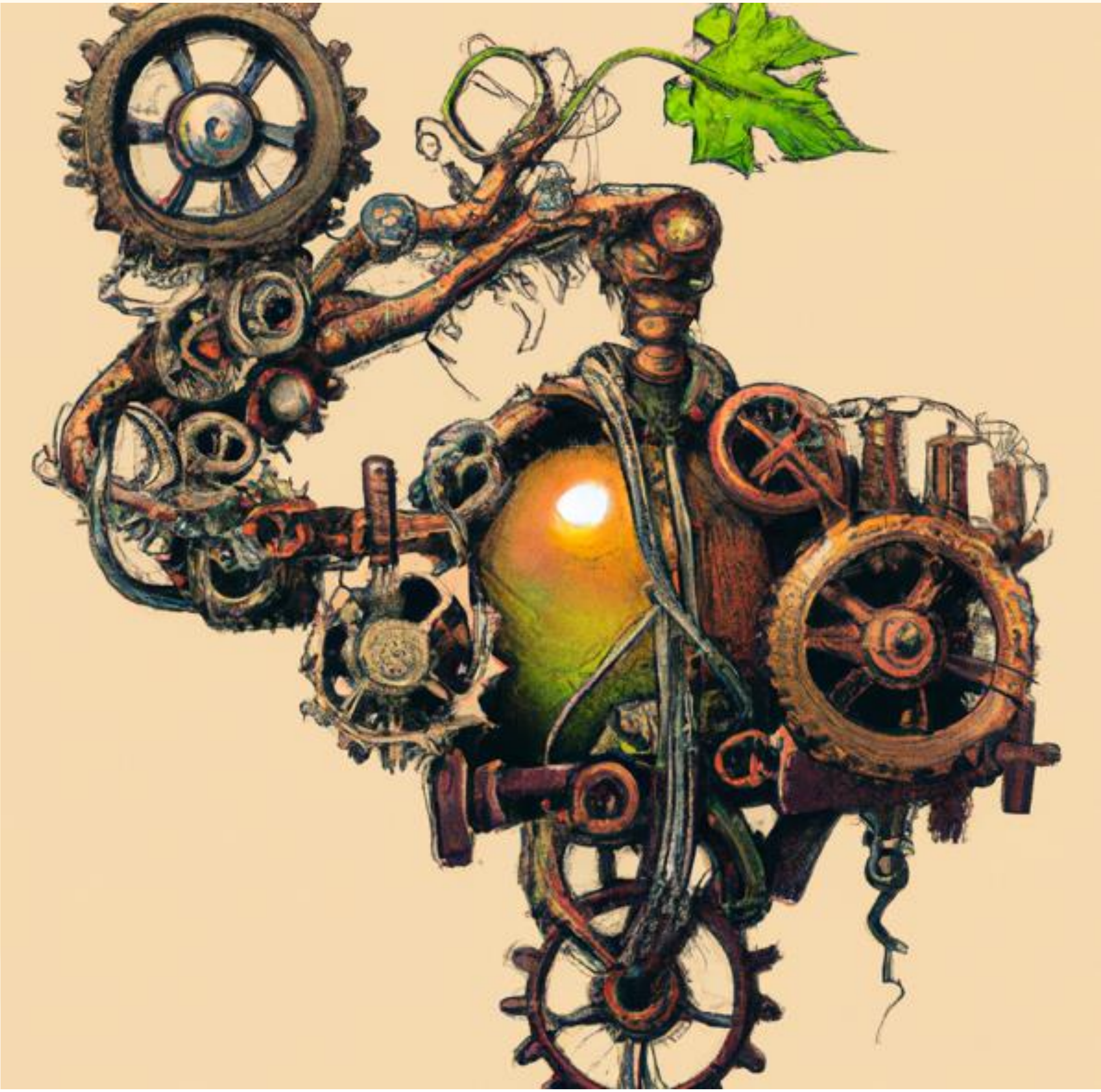
Vineyard Health

- **Vine Function ≈ Vine Health**

- Important Vine Functions
  i. Photosynthesis
  ii. Vascular system
  iii. Reproductive efficacy
  iv. Physical support



Vineyard Health

- **Photosynthesis**
  - Source = Leaves
  - Rate = Vigor & canopy size
  - Dependencies
    1. Resource availability
    2. Vascular function
    3. Minimal stressors
    4. Light availability

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Photosynthesis

Requirements for Photosynthesis

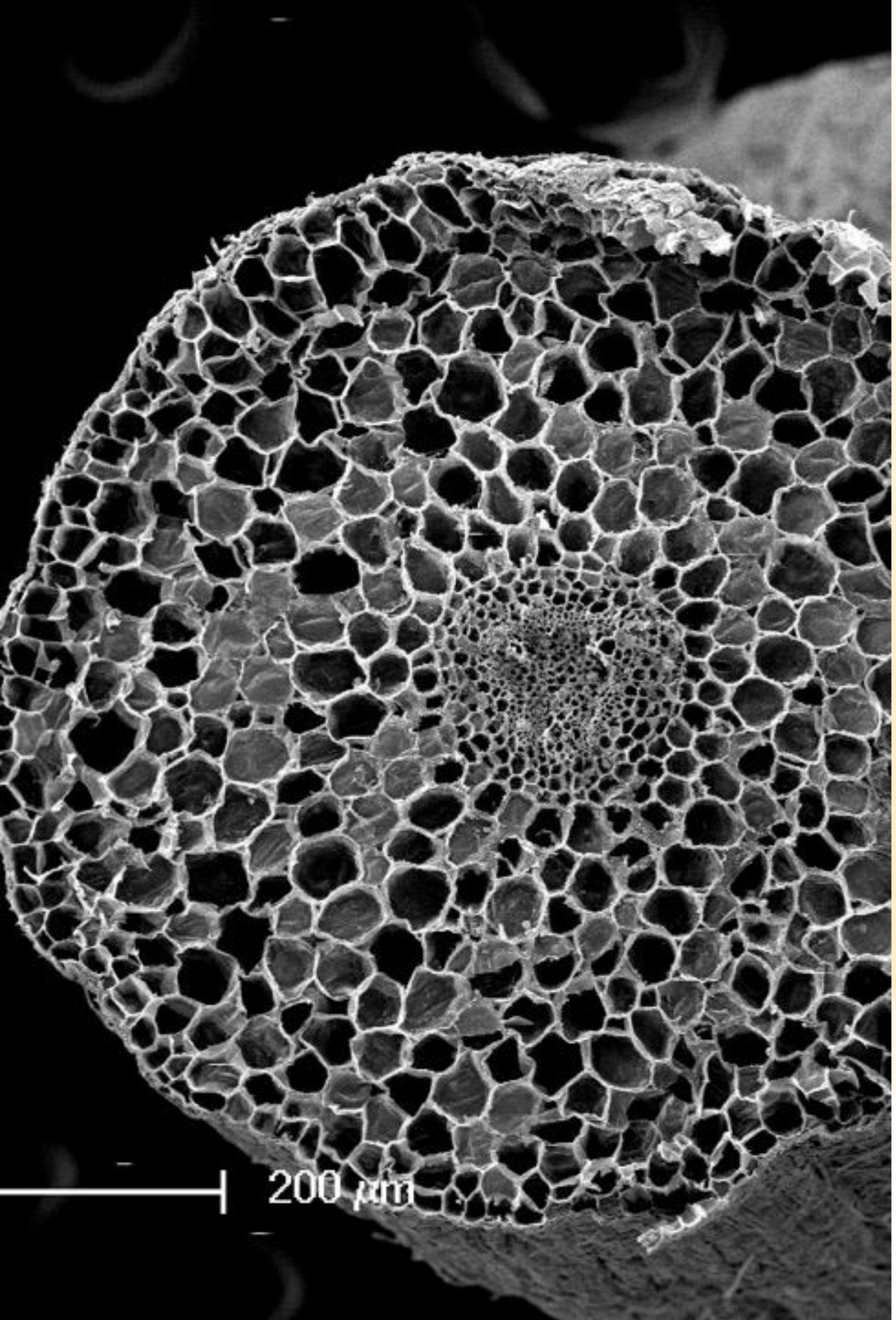
- 'Clean' leaf surfaces
- Open stomata
- Light (Solar radiation)
- Water
- CO_2

Photosynthesis under Smoke-Conditions

Requirements for Photosynthesis

- ~~‘Clean’ leaf surfaces~~
- ~~Open stomata~~
- ~~Light (Solar radiation)~~
- Water
- CO_2

Smoke Impacts on Grapevine Physiology



Physiological impact of abiotic stressors

1. Heat stress:
   - Increases vine water demand
   - Increases vine respiration
   - Timing of heat stress can increase foliar growth
     i. Resulting in more sugars for phytophagous insect pests
2. Drought stress:
   - Can result in whole-vine oxidative stress
   - Polyphenol synthesis increases (abiotic stress response)
   - Modified morphological and phenological characteristics
     i. e.g., xylem vessel size and hydraulic conductivity

Effects of smoke on gas-exchange & photosynthesis

Three parameters of photosynthesis affected by smoke exposure

1. Stomatal Conductance (g_s)
2. CO_2 assimilation rates
3. Intercellular CO_2 levels

However, reductions in these functions are short term

Plants can acclimate to the smoke-exposure within 24 - 48 hours

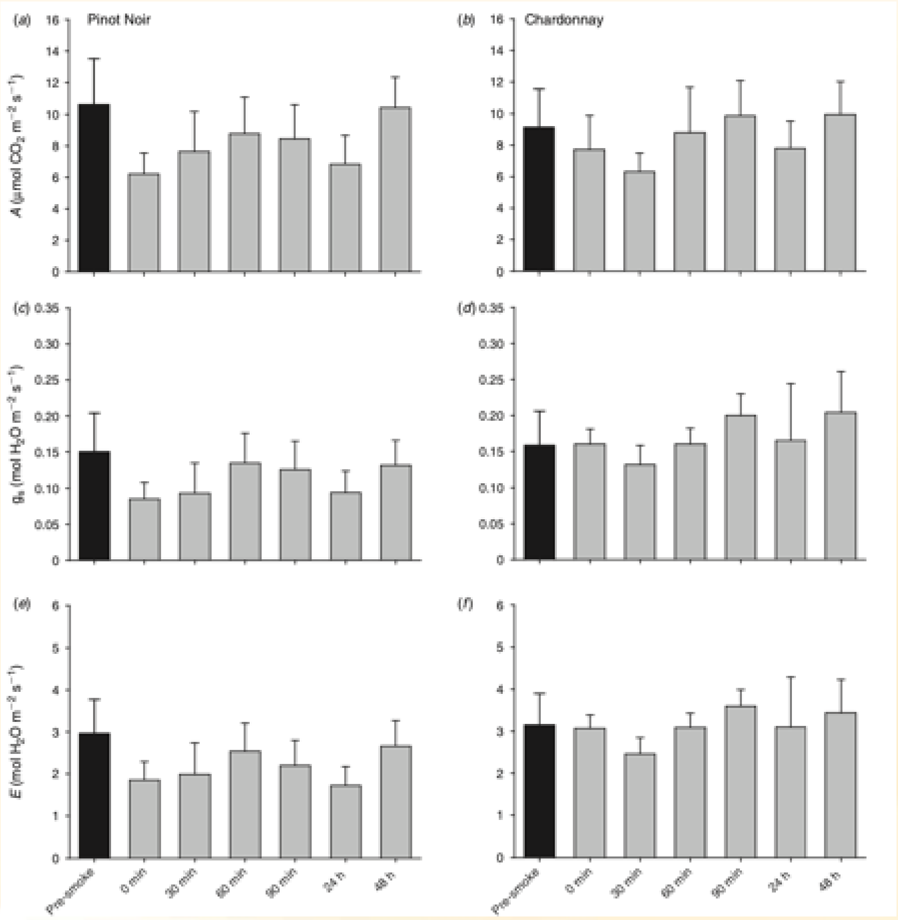
Gilbert and Ripley 2022

Effects of smoke on gas-exchange & photosynthesis

Fuel type matters for the short-term responses observed in gas exchange

- Research has observed a difference in grapevine stomatal conductance impacts depending if smoke comes from Coast Live Oak or Eucalyptus species (Bell et al. 2013)

Overall, the impacts of smoke *by itself* on gas exchange and photosynthesis are transitory and can be self-corrected by the vine



Bell et al. 2013

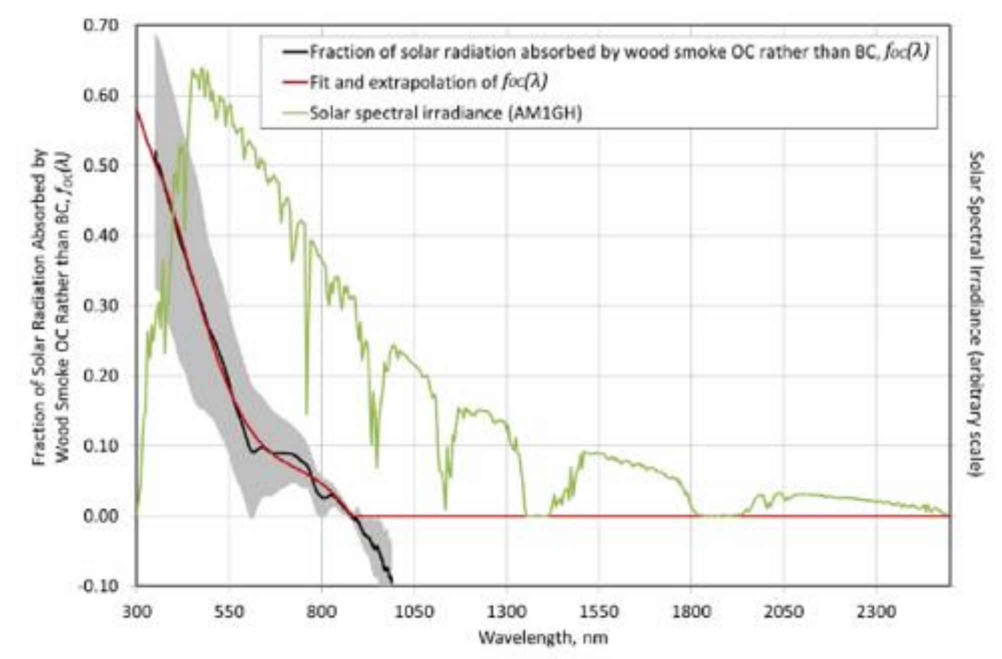
Effect of smoke on light-availability

While smoke itself may not have a significant impact on photosynthesis, particulate matter from smoke can

Wood smoke has been shown to absorb solar radiation with specific spectral selectivity (Kirchstetter and Thatcher 2012)

- Ultraviolet to visible spectrum absorption

Up to a 50% reduction in UV-light and Visible-light



Kirchstetter and Thatcher 2012

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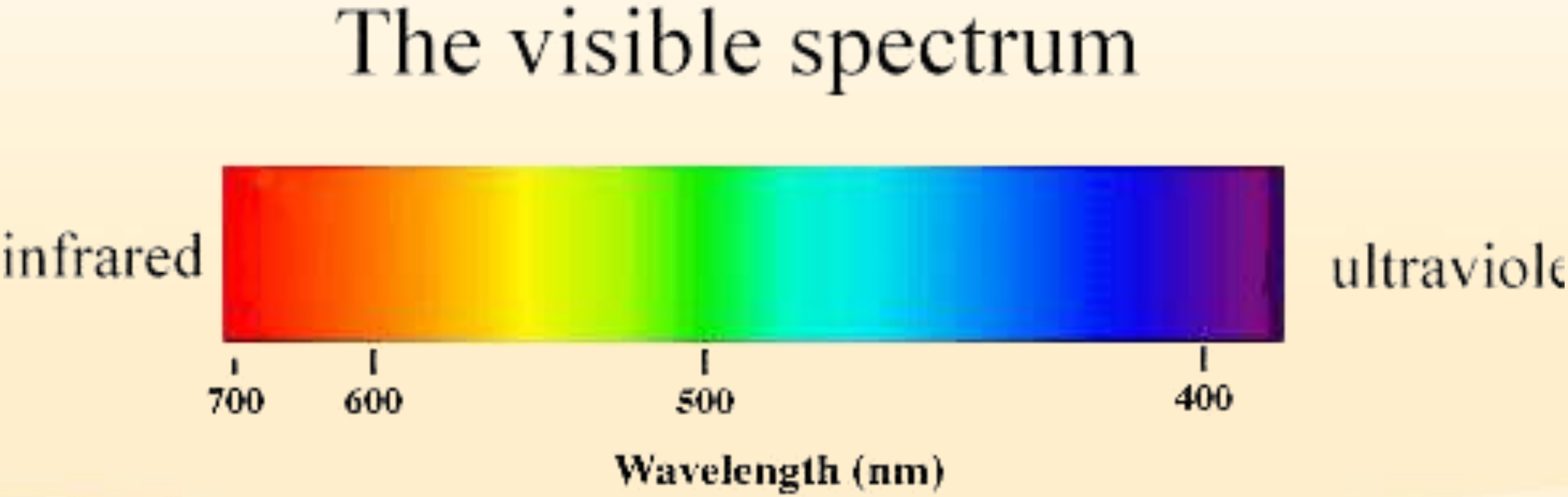
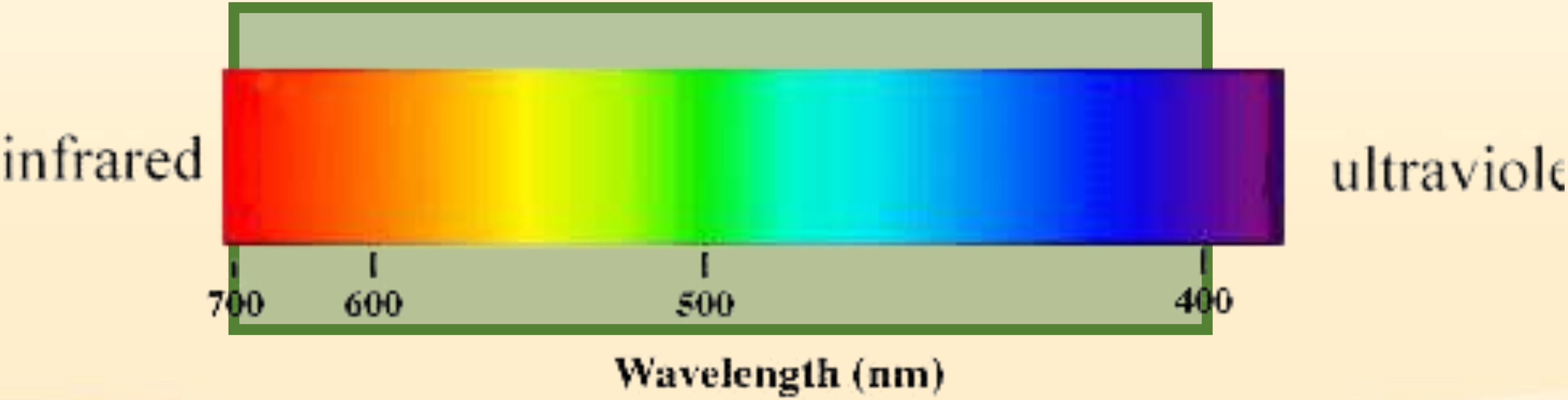
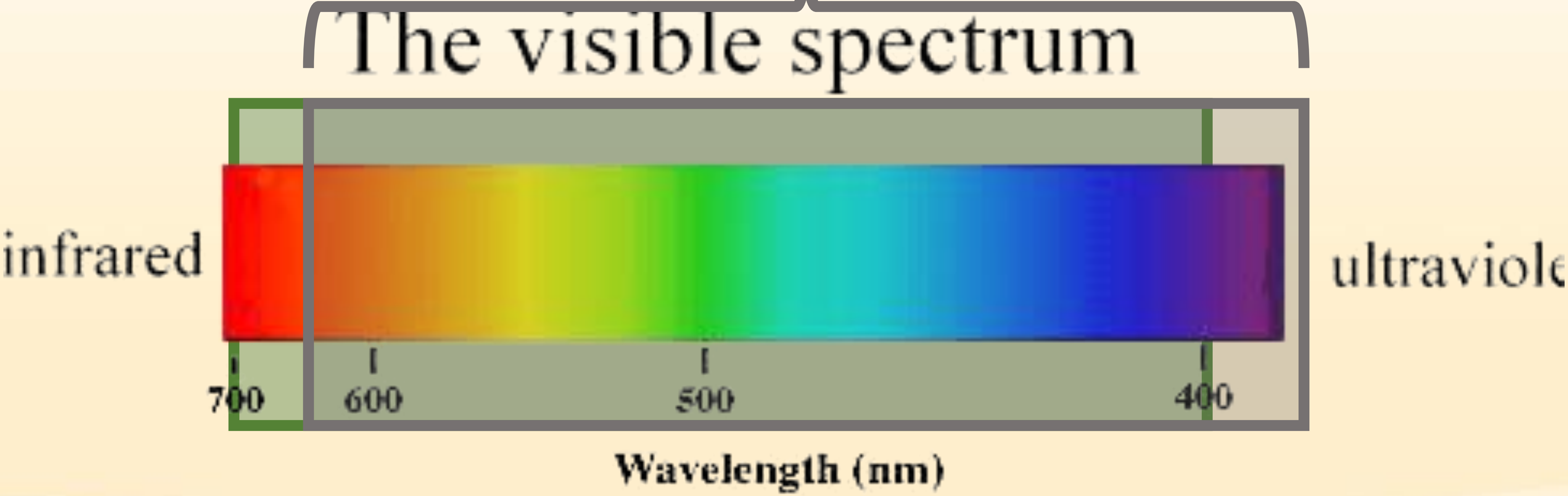

The visible spectrum
infrared
ultraviole
700
600
500
400
Wavelength (nm)

The visible spectrum



Photosynthesis

Wavelengths reduced from wildfire smoke



Photosynthesis

Effect of smoke on surface temperatures

Because wood smoke preferentially filters light in the UV and Visible spectrums

- **Most Infrared light makes it down to the surface**

Most of the heat-imparting effects of solar radiation come from the Infrared spectrum

There is **little to no decrease in surface temperatures** under high-instances of smoke particulate matter

Tarasova et al. 1999

Effects of Smoke on Fruit

Volatile phenols

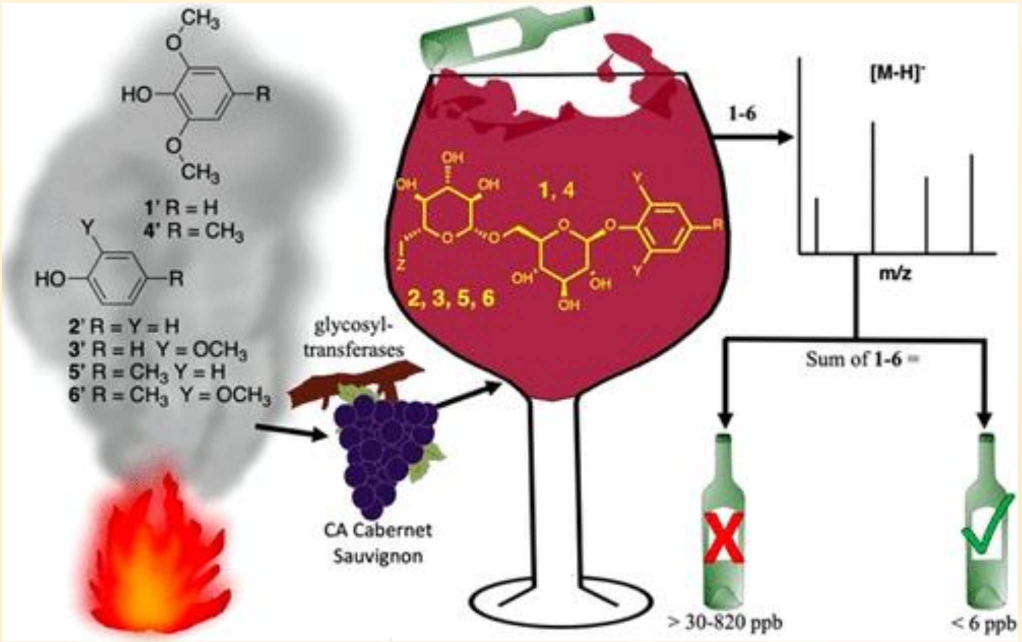
- Smoke derived compounds associated with burning vegetation.
- Absorbed through the skin of ripening grapes and accumulate by binding to sugars
- Bound by a native grape enzyme: glycosyltransferase
- Results in Phenolic Diglycosides

Härtl and Schwab 2018 (Article)

Effects of Smoke on Fruit

Phenolic Diglycosides

- A **nonvolatile compound** (volatile phenols bound to sugars)
- Stable compound while bottle aging (sticks around)
- Cannot be smelled or tasted while still in bound form
- Can be **released by enzymes during fermentation or in the mouth**



Crews et al. 2022

Preliminary Work

Smoke Risk from Prescribed Burns

Fire Risk in California

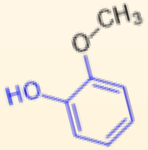
An average of ≈ 5,000 acres burn to wildfire in CA each year (CalFire/ USFS)

≈ 70,000 acres of land are burned in a controlled/prescribed manner each year to limit wildfire risk (CalFire/ USFS)

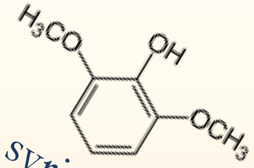
Removing ground litter and fuel source build up is essential to reduce wildfire intensity and frequency

Existing Knowledge

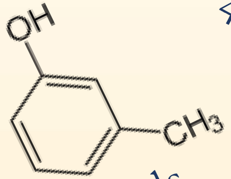
- Fuel source lignocellulose content affects VOC production
- Trees and woody species have more lignocellulose and burn hotter than vegetative species
- Increasing distance and time suspended in air affects smoke taint risk in grapevines



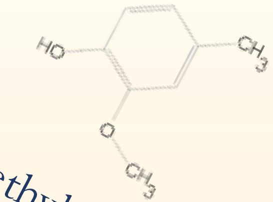
guaiacol



syringol



cresols



4-methyl guaiacol

Woody and Vegetative Tissues

Only Vegetative Tissues

(Sources : Adeboye et al., 2014; Kolb et al., 2013; Tao et al., 2020; Zhu et al., 2022)

Preliminary Study
Hopland REC

I’ve received calls each year from concerned clientele whenever a prescribed burn occurs nearby their vineyard

Actual risk to vineyards needed to be assessed

Preliminary study conducted in Autumn 2024

Grass and forb fuel sources

- Less lignocellulose than hardwoods

PurpleAir Flex[tm]
Smoke Sensor

Before

After

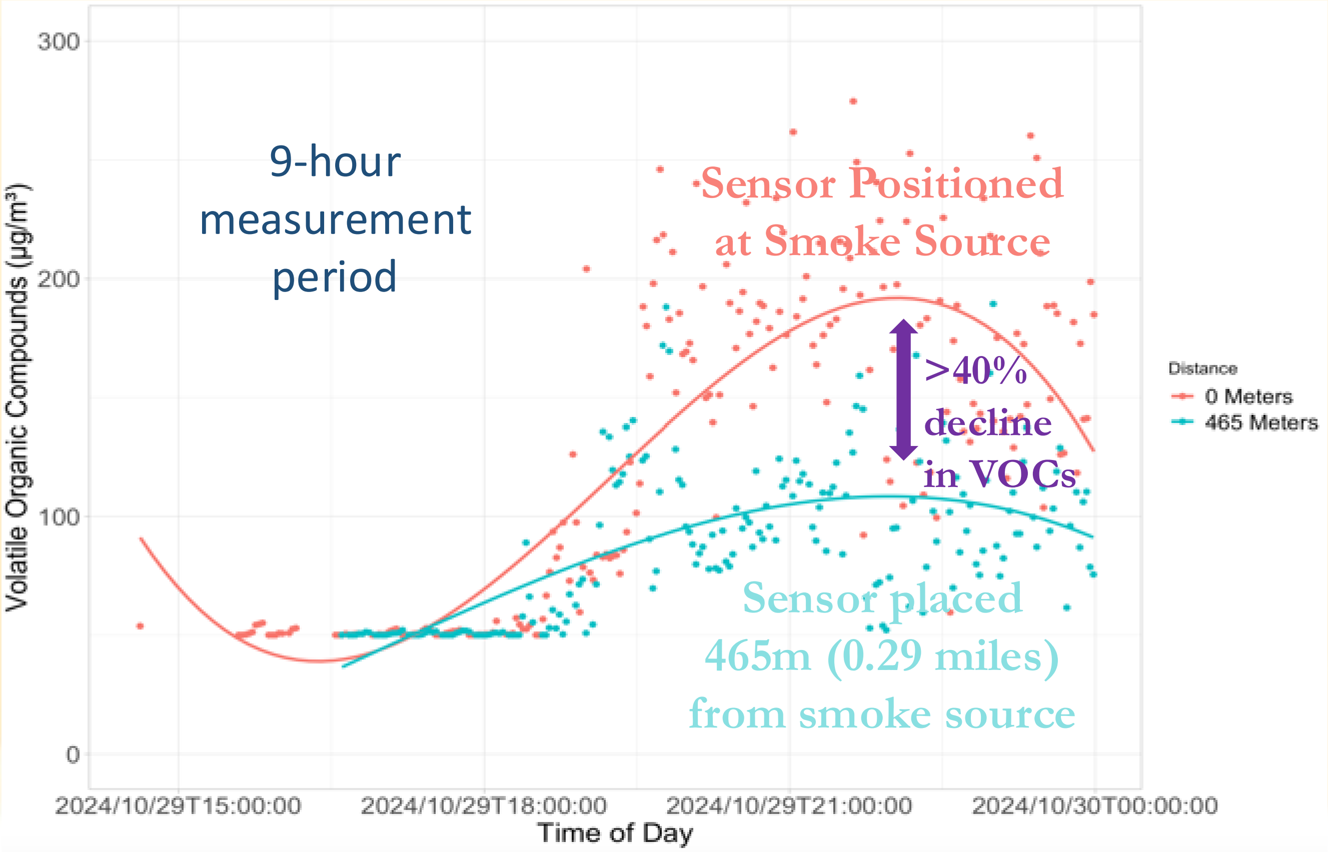
Results – HREC Prescribed Burn (2024)

Concentration of VOCs reduced by 31% on average at 465 meters (0.29 miles) away from smoke source

> 40% decline in airborne VOCs at time of maximum smoke output

Not the full picture of risk

Decline in VOCs at <0.5 miles from source of smoke is temporary



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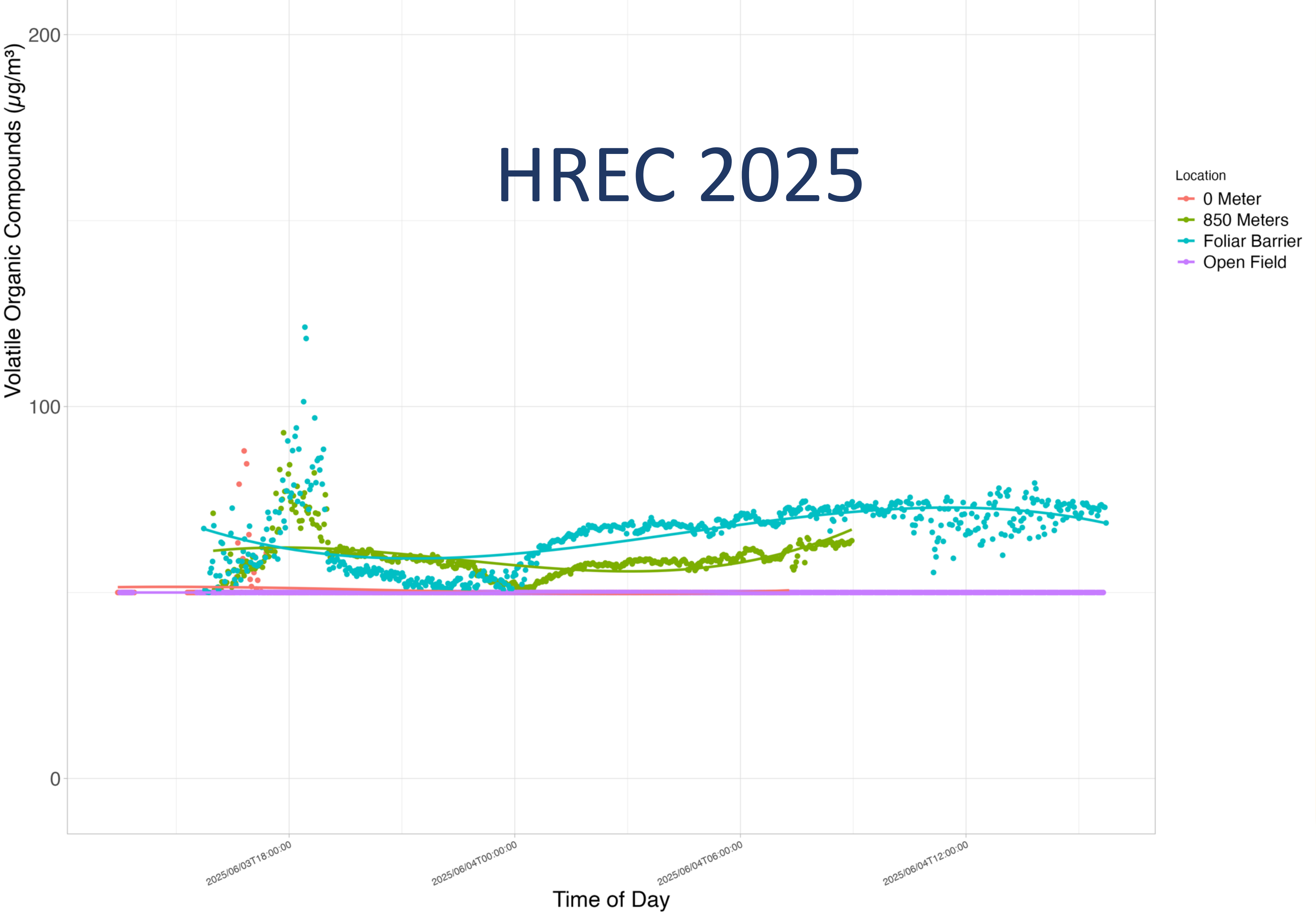
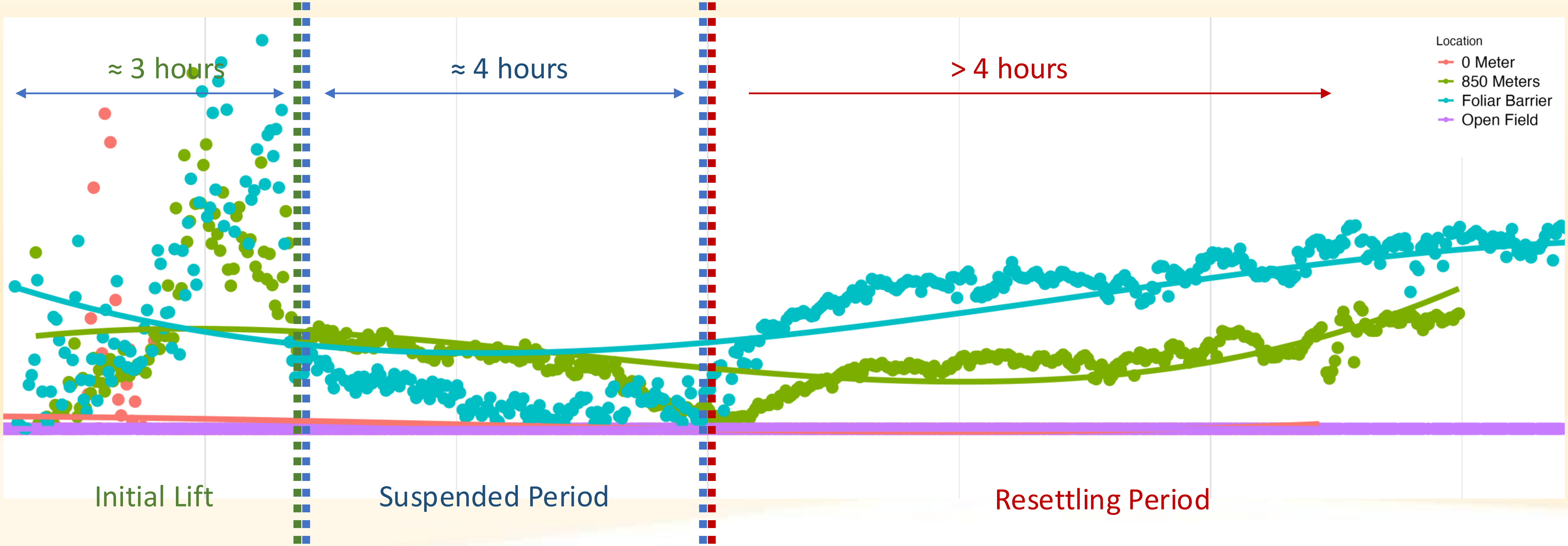

HREC 2025
Volatile Organic Compounds (µg/m³)
200
100
0
2025/06/03T18:00:00
2025/06/04T00:00:00
2025/06/04T06:00:00
2025/06/04T12:00:00
Time of Day
Location
0 Meter
850 Meters
Foliar Barrier
Open Field

HREC 2025



≈ 3 hours
≈ 4 hours
> 4 hours
Location
0 Meter
850 Meters
Foliar Barrier
Open Field
Initial Lift
Suspended Period
Resettling Period

Preventative Management Strategies

Forests

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

Forests can be used as a ‘smoke-break’ and bind the volatile phenols before they reach your grapes

Particulate clay barriers – Kaolin

Foliar application of kaolin can reduce the concentration of volatile phenols in smoke-exposed fruits (van der Hulst et al. 2019)

Efficacy depends on the rate of kaolin application and extent of coverage

Some results are inconclusive, but this may work as a preventative measure (Szeto et al. 2022)

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Biofilms

Fungal pathogen sprays applied 1 week before smoke exposure may help prevent accumulation of volatile phenols in nearly-mature grapes

Artificial grape cuticle (Favell et al. 2019)

Other spray-on films being tested now

- Cellulose nanofiber films (CNFs)
- Chitosan (fibrous polysaccharide)

Canopy Management

Leaf removal (Ristic et al. 2013)

- Post-smoke exposure
  - Decreased intensity of smoke characters in wines relative to controls
- Pre-smoke exposure
  - Exposed grapes and increased smoke taint intensity in wines

Similar effect to the 'Forest Canopy Barrier' concept

Volatile phenols will bind to the leaf as well as the fruit; serves as a barrier against smoke before contact with the fruit

Fabrics

Activated Carbon Fabrics (Wilkinson et al. 2022)

- Have been tested as a protectant against volatile phenols in grapes
- Activated carbon is commonly used in water and air filtration
- These trap volatile phenols well
- However, wrapping each cluster in a bag made of activated carbon may be prohibitively costly to the grower

Response Strategies

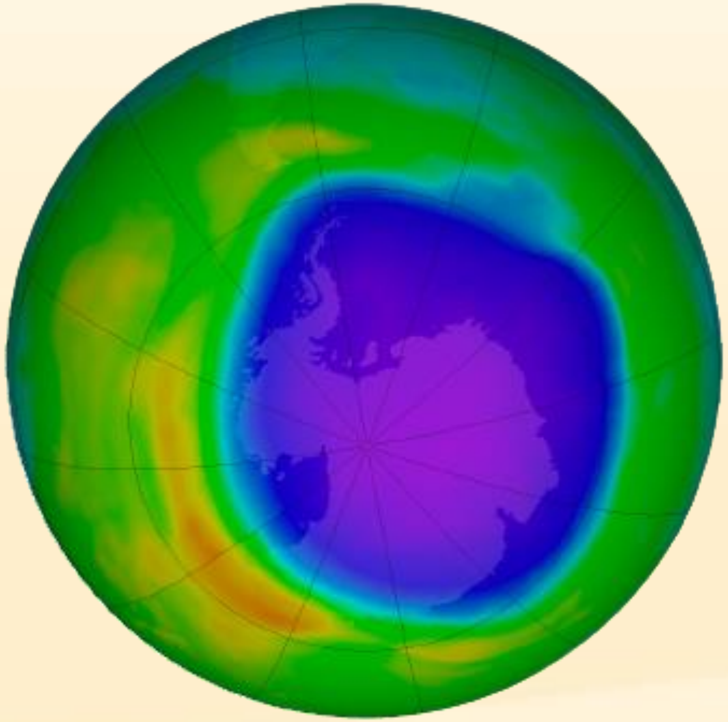
Fire and Smoke in Vineyards

Ozone (O_3) Treatments

Researchers are examining exposure to **gaseous ozone** (O_3) to mitigate the intensity of smoke taint in affected grapes

At 1ppm O_3 exposure for 24 hours one experiment saw a significant decrease in volatile phenols and phenol glycoside concentrations (Modesti et al. 2021)

Decreases in sensory perception of smoke taint in wine were also observed in this study



Remote Sensing - Contamination Detection

Fuentes et al. 2019

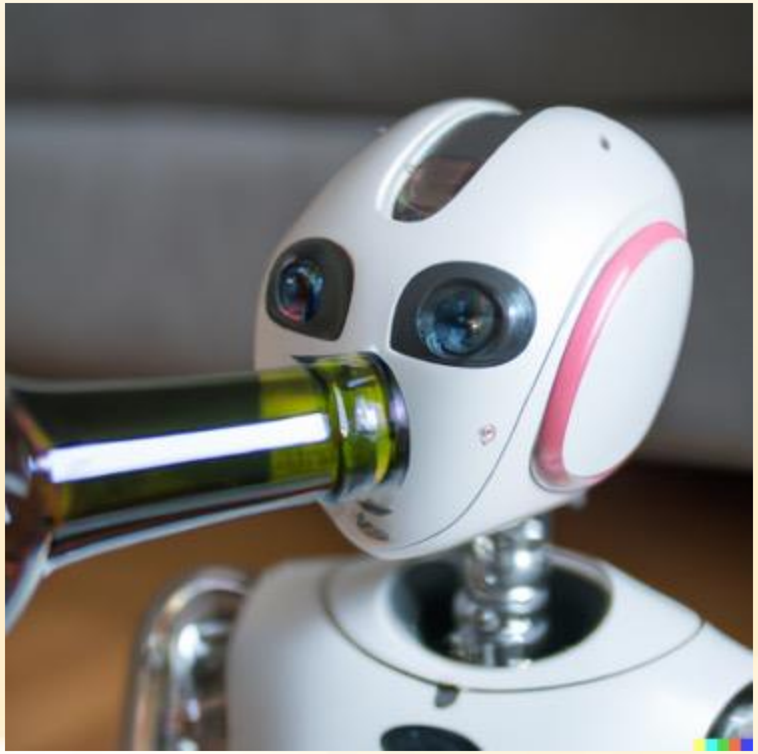
- Non-invasive detection of smoke contamination in grapevine canopies **in-field**.
- Using a machine-learning model to identify **predictable changes in stomatal conductance** (g_s)
- Second method to identify levels of phenolic diglycosides in fruit and wine using **near-infrared spectroscopy (NIR)**
- Data can be collected with **drones** and is up to **96% accurate**

Artificial Intelligence - Contamination Detection

Fuentes et al. 2020

- Sensor data can be **monitored by AI** to identify signs of smoke contamination using the remote sensing methods.

- Further development of an **‘electronic nose’** to identify volatile phenols and gases in wines and vineyards.



Summary

1. Climate change is unpredictable
2. Smoke exposure has short-term impacts on photosynthesis and gas exchange in vines
3. Binding of volatile phenols as phenolic diglycosides makes the smoke characteristics stable in the fruit
4. Mitigation is possible with emerging response-management strategies

Thank You

Presentation Available

You can find the sources for this presentation at:

1. https://ucanr.edu/site/ucce-north-coast-viticulture
2. Speaker Presentations

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