

Prescribed Burn Risks to Vineyards

UCCE North Coast Viticulture

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North Coast

Fire Risk in California

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

$\approx 70,000$ 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

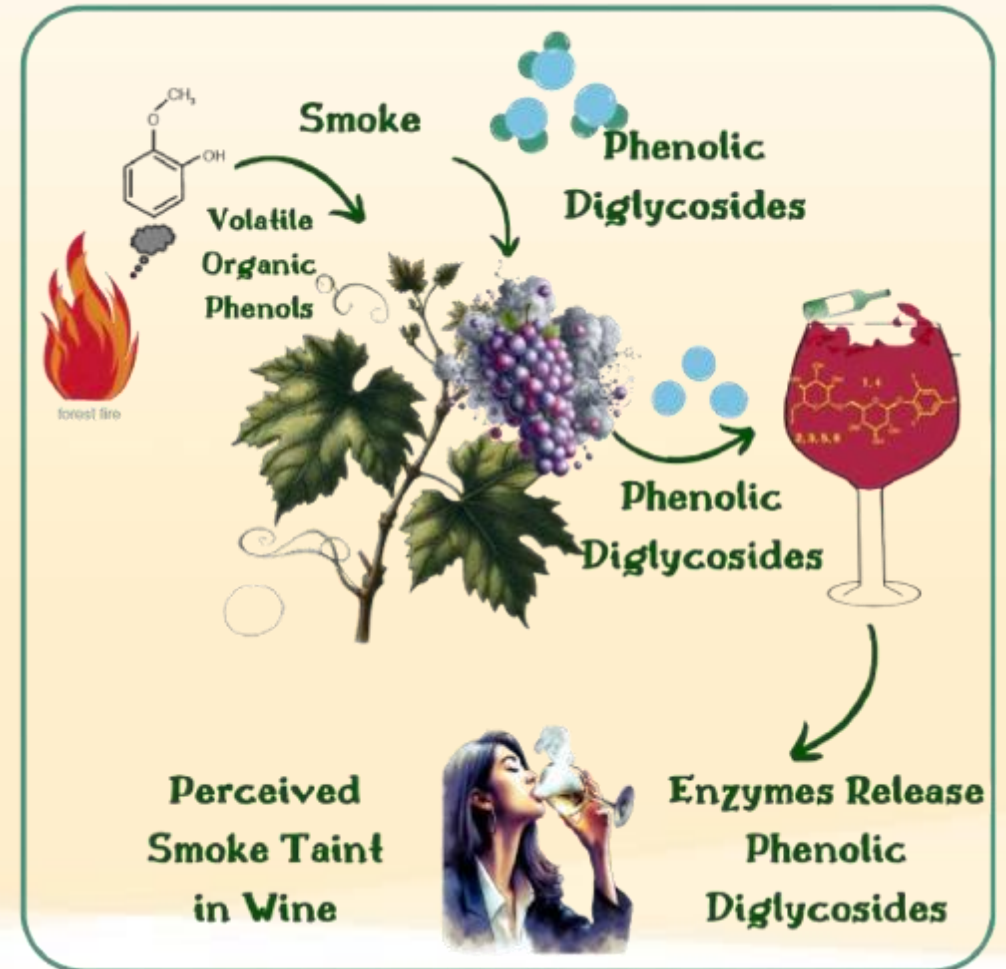


Smoke Taint in Vineyards

Smoke taint in grapes can result in significant losses to harvestable fruit

- 2020 smoke damage resulted in 165,000-325,000 tons unharvested CA
- Each year, fruit is damaged beyond salvage due to smoke exposure

Volatile organic compounds (VOCs) in smoke bind to plant tissue and impart an “ash tray” like flavor to the wine



UCCE Viticulture Handout (2024)

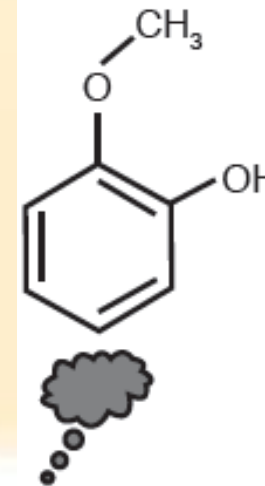
Effects of Smoke on Fruit

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



forest fire

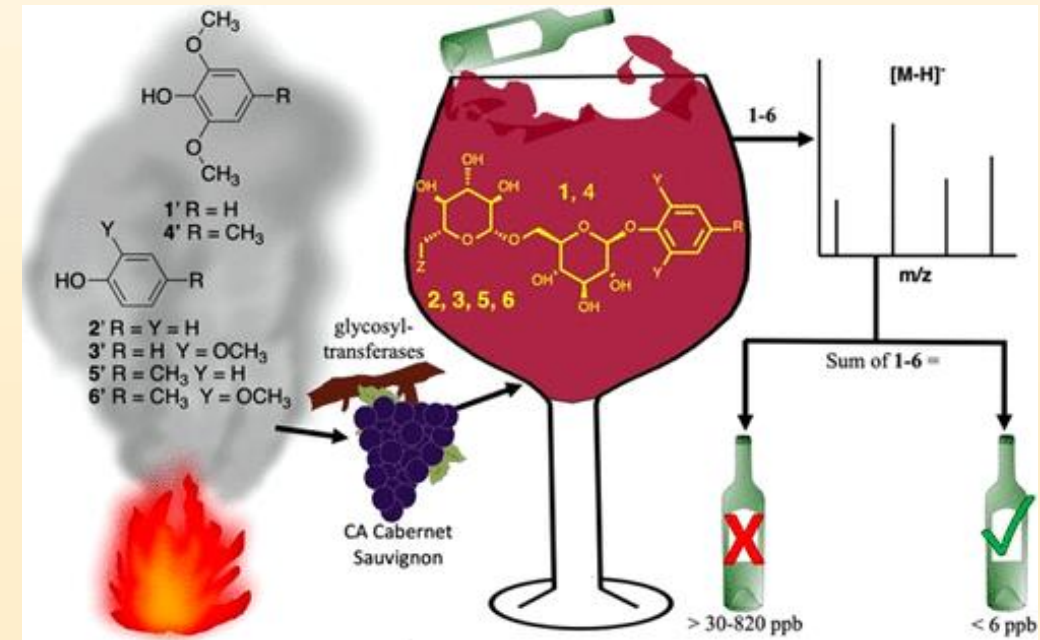


Härtl and Schwab 2018 (Article)

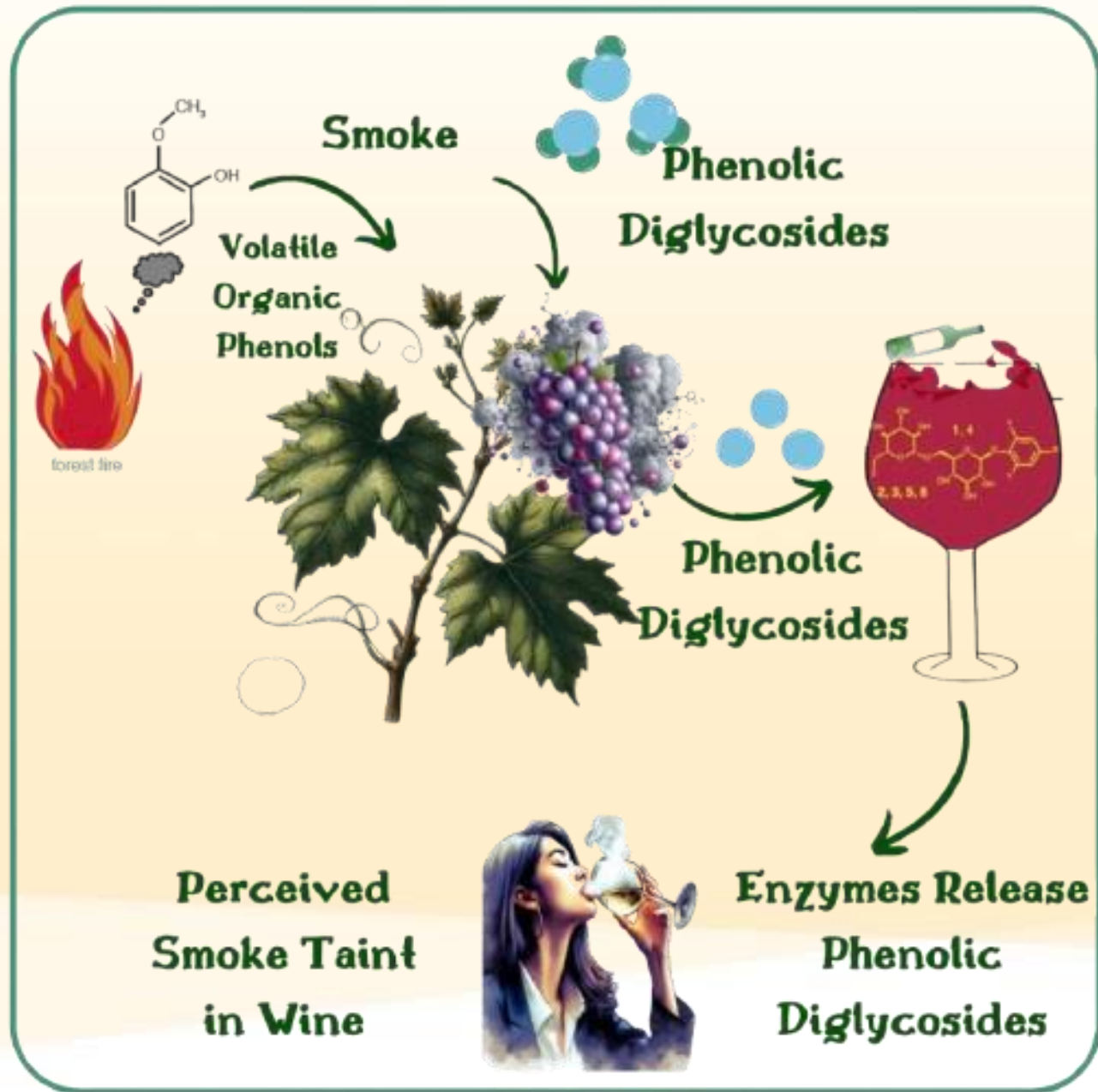
Effects of Smoke on Fruit

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



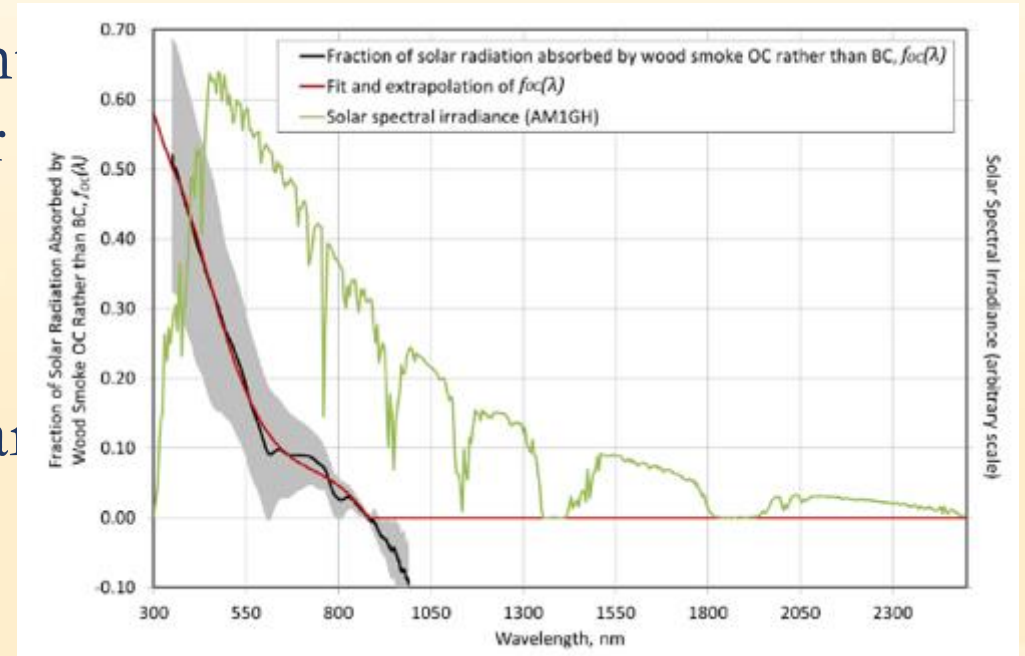
Effect of smoke on light-availability

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)

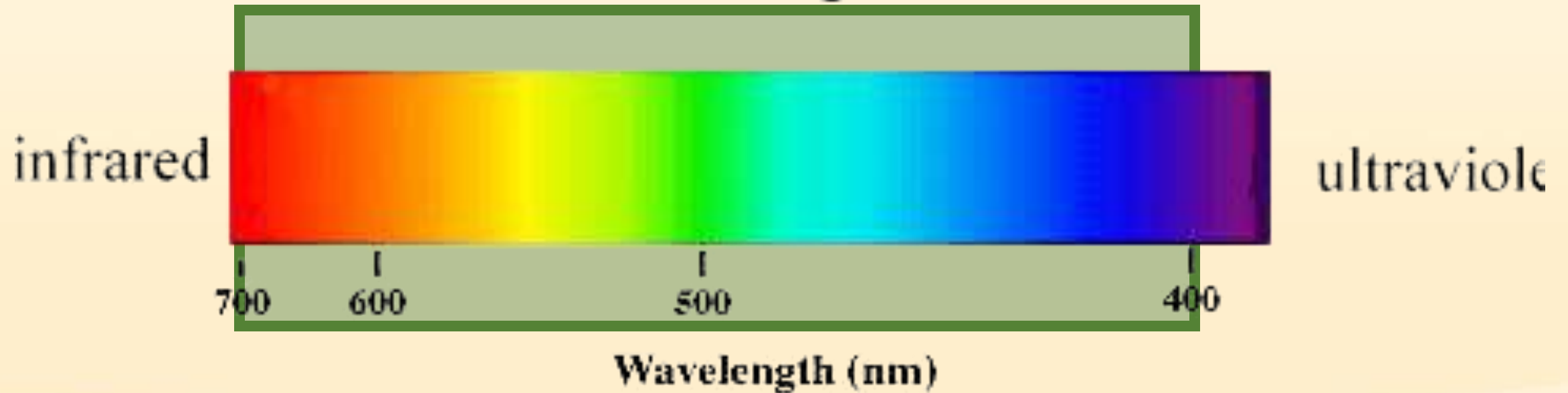
- Ultraviolet to visible spectrum absorption

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



Kirchstetter and Thatcher 2012

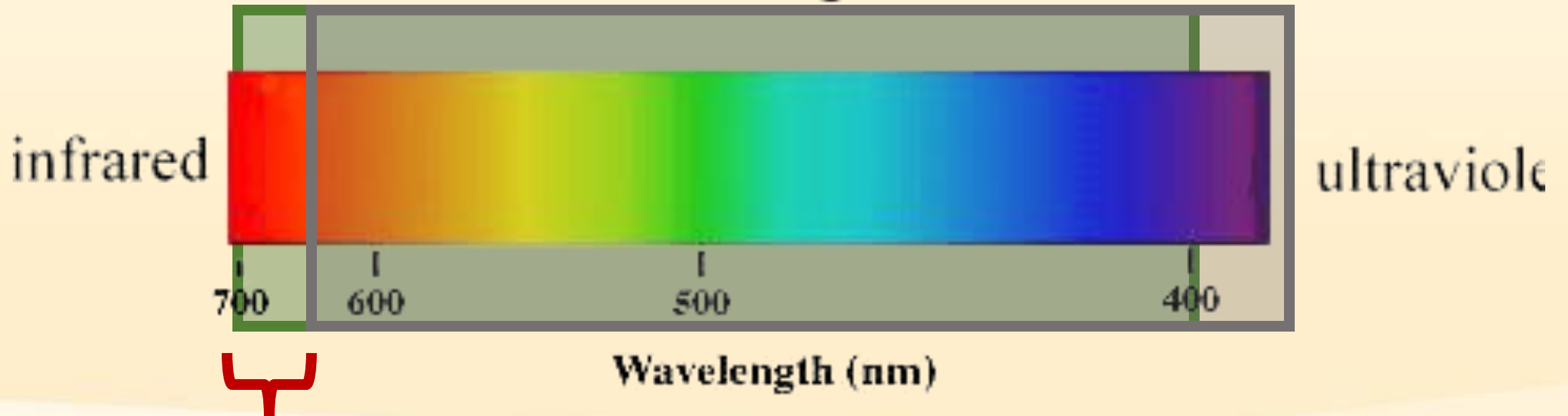
The visible spectrum



Photosynthesis

Wavelengths reduced
from wildfire smoke

The visible spectrum



Wavelengths responsible for
most temperature gains

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

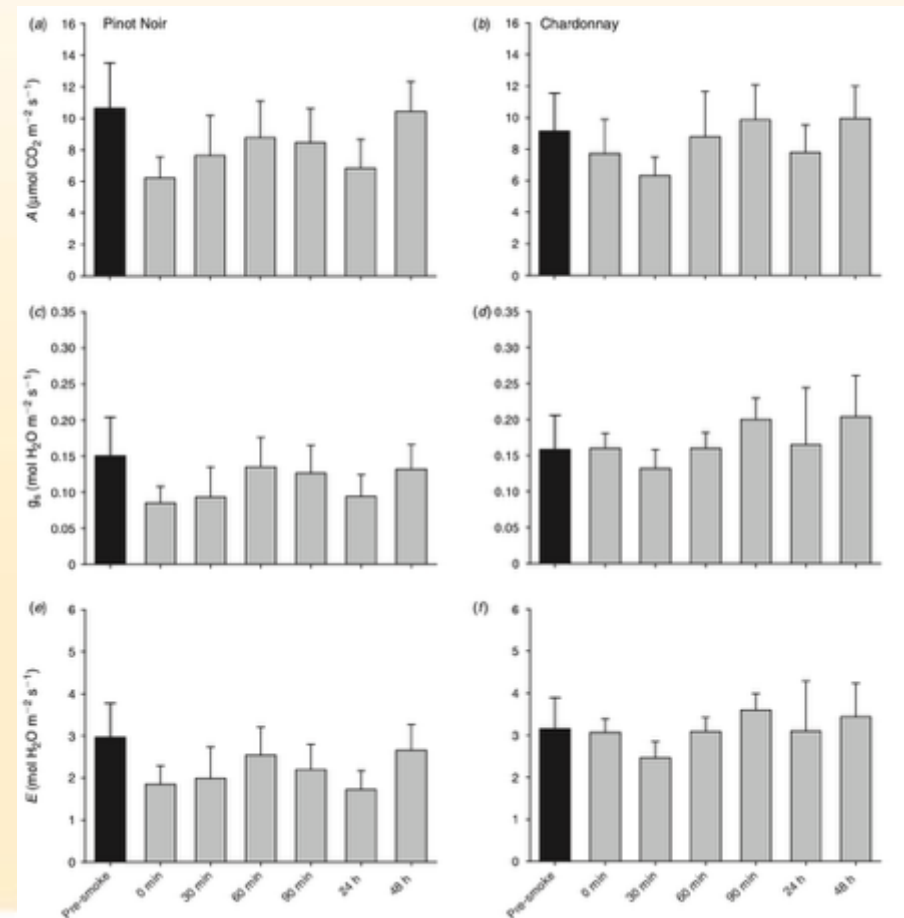


Effects of smoke on gas-exchange & photosynthesis

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

Preventative Management Strategies

Forests

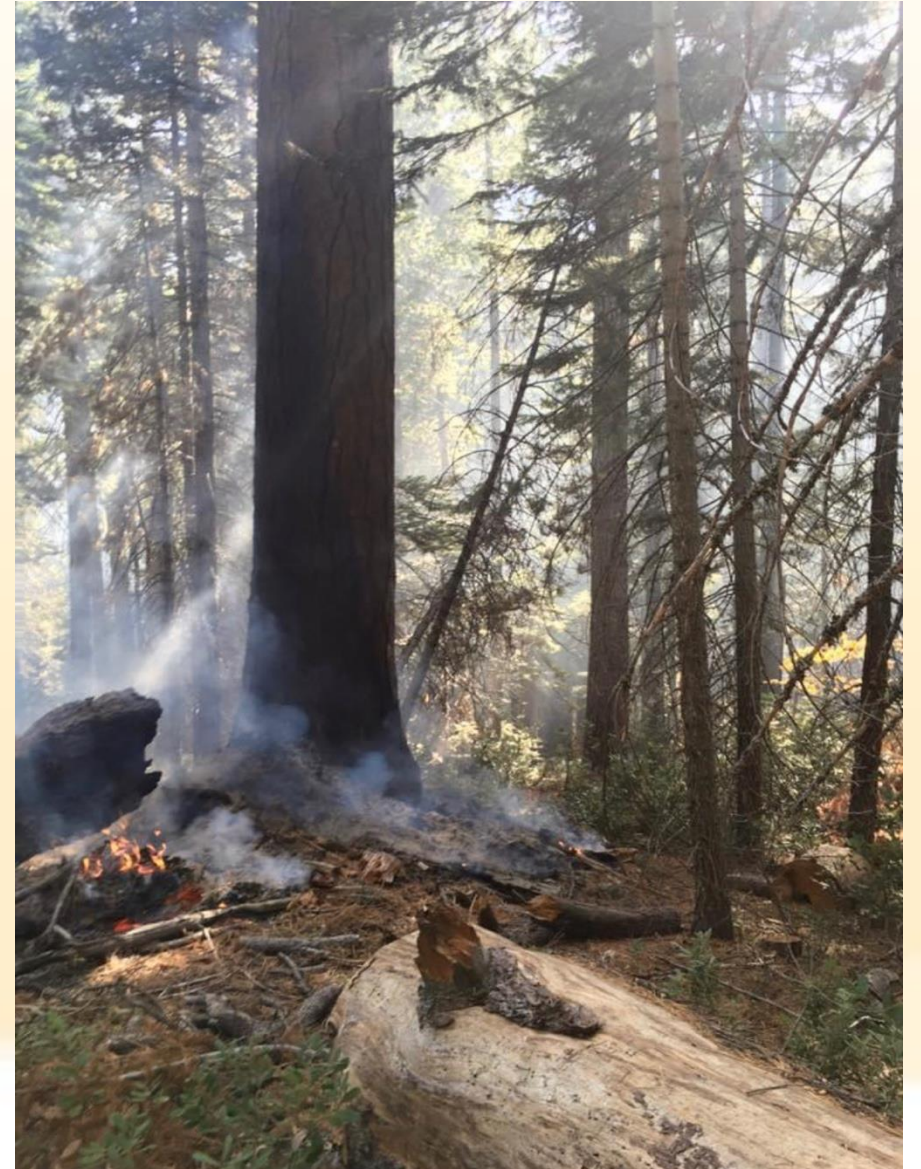
Proper forest management can reduce the risk of smoke damage

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)



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)

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

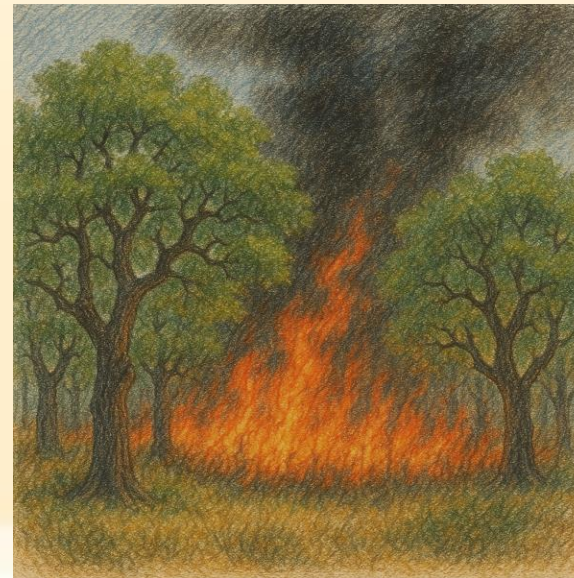
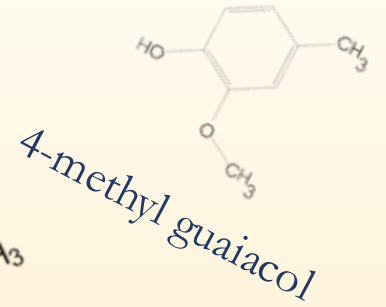
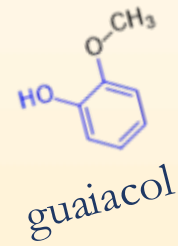
Activated Carbon Fabrics (Wilkinson et al. 2022)

- 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



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



Woody and Vegetative
Tissues



Only Vegetative
Tissues

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 and Spring 2025

Grass and forb fuel sources

- Less lignocellulose than hardwoods

PurpleAir Flex™
Smoke Sensor



Before



After

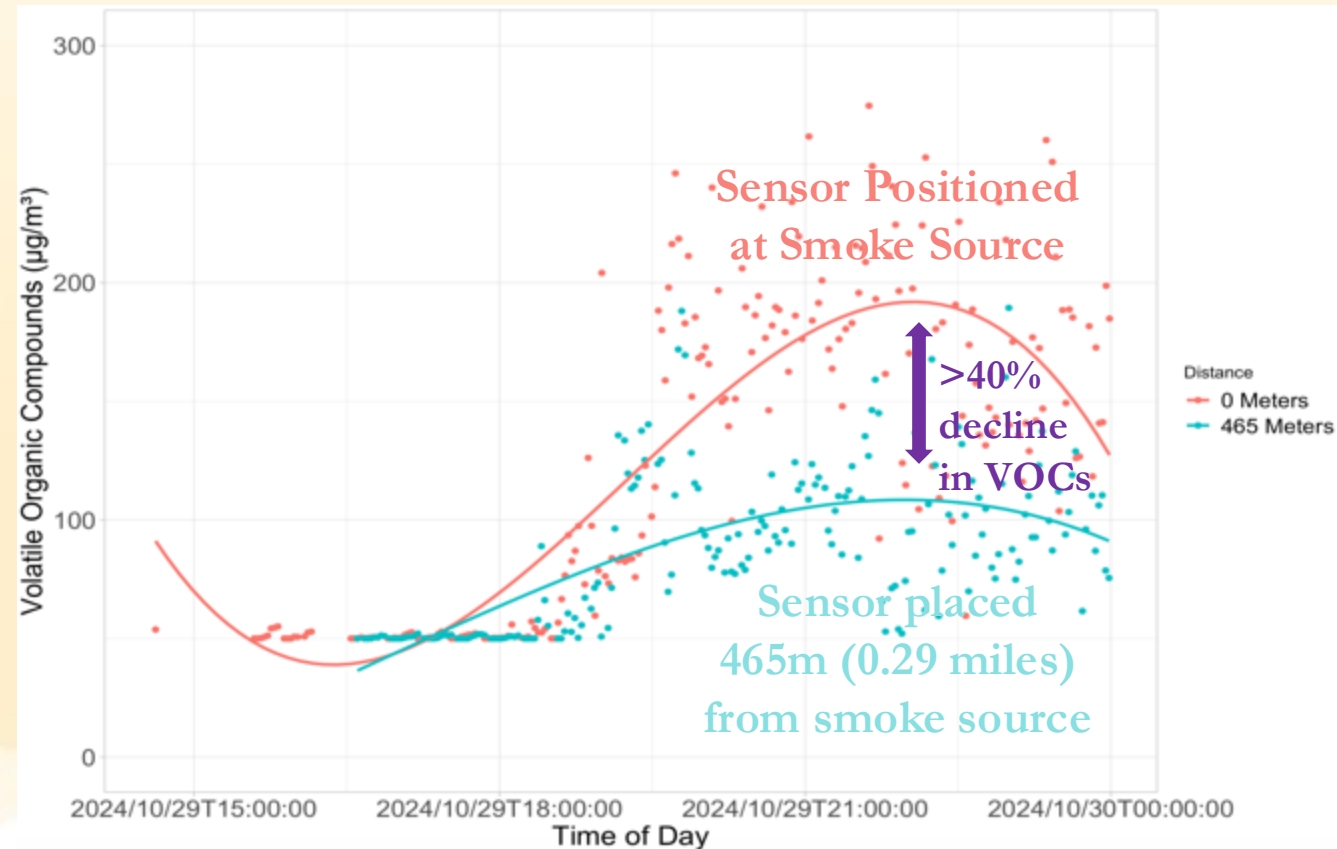
Results – HREC Prescribed Burn

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

Still a significant risk to vineyards

Decline in VOCs at <0.5 miles from source of smoke is a useful finding for CA vineyards to assess risk



Results – HREC Prescribed Burn (Year 2)

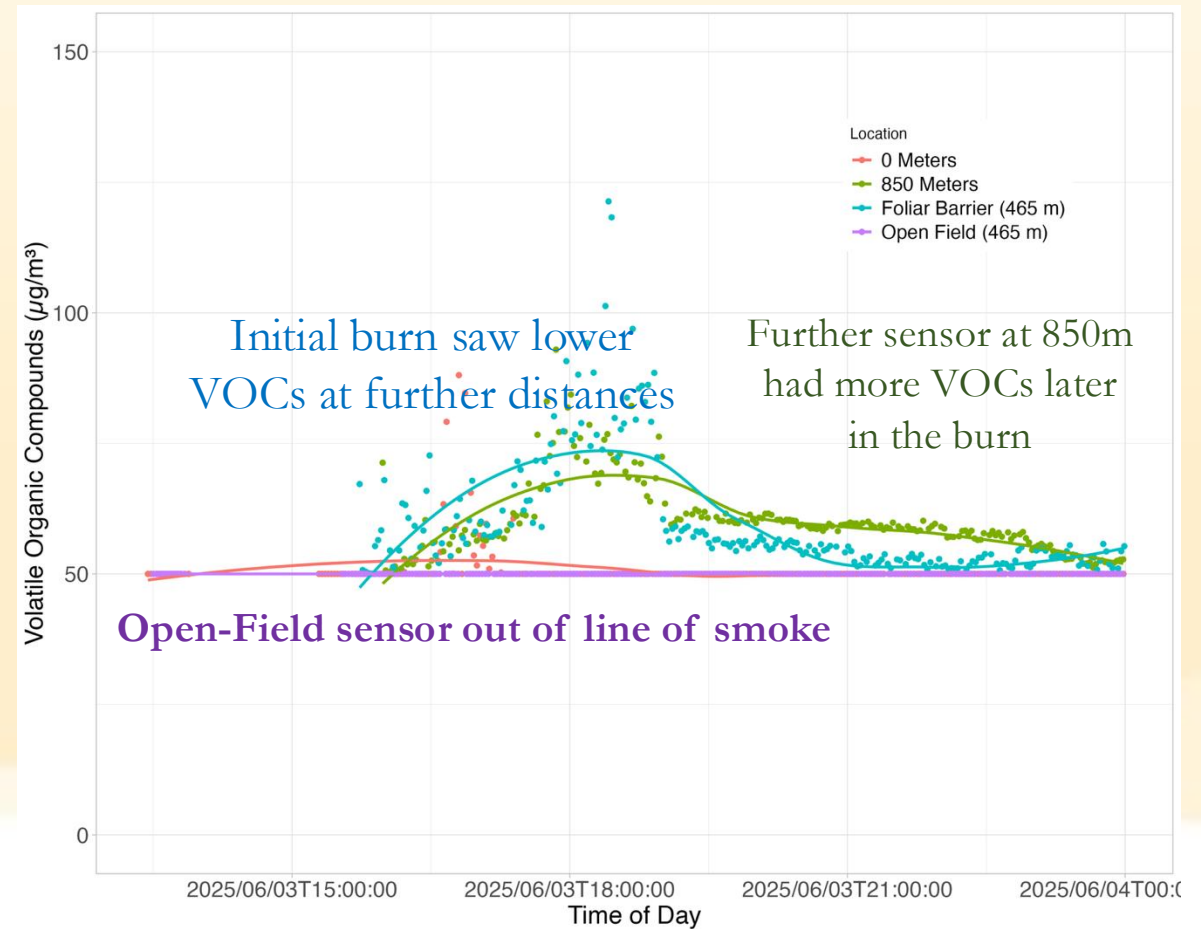
Wind direction is challenging

Original goals:

- Identify impact of foliar barriers
- Measure effect of distance on VOCs

Work in progress...

Plan to move forward again next year



Impacts to local stakeholders

Helps growers estimate their risk when prescribed burns occur

Allows those burning to better understand the impact of distance and fuel sources

Alleviates some fear of crop damage from fire-safety practices



UC Davis Oakville Research Station (2017)

Future Plans

Seeking funding for larger assessment in 2025-2026 cycle to occur at HREC

Will assess VOC production of various vegetative-species compositions commonly burned

Plan to assess the influence of foliar barriers and quantify the reduction in VOCs by distance from source



Summary

1. Prescribed burns are a valuable tool for limiting the impacts of wildfire
2. Smoke exposure has short-term impacts on photosynthesis and gas exchange in vines and can cause direct fruit damage via smoke-taint
3. Binding of volatile organic compounds as phenolic diglycosides makes the smoke characteristics stable in the fruit
 - Often these PDs are released by enzymes in the mouth of humans
4. Preliminary work at HREC measured a significant reduction in smoke-carried VOCs at short distances during a prescribed grassland burn event
5. Future work will include a better assessment of the effect of distance as well as influence of foliar barriers on airborne VOC persistence

Downloadable Presentation

You can find this presentation at:

1. <https://ucanr.edu/sites/chenlab>
2. “Speaker Presentations” Page
3. “2025 UC Cooperative Extension” section





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

References

- Adeboye, P. T., Bettiga, M., & Olsson, L. (2014). The chemical nature of phenolic compounds determines their toxicity and induces distinct physiological responses in *Saccharomyces cerevisiae* in lignocellulose hydrolysates. *AMB Express*, 4(1), 46. <https://doi.org/10.1186/s13568-014-0046-7>
- CALFIRE. (2025). Statistics. California Department of Fire and Forest Protection, Sacramento, CA. <https://www.fire.ca.gov/our-impact/statistics>
- Kolb, M., Schieder, D., Faulstich, M., & Sieber, V. (2013). Analysis of lignocellulose derived phenolic monomers by headspace solid-phase microextraction and gas chromatography. *Journal of Chromatography A*, 1307, 144-157. <https://doi.org/https://doi.org/10.1016/j.chroma.2013.07.094>
- Tao, W., Yang, X., Li, Y., Zhu, R., Si, X., Pan, B., & Xing, B. (2020). Components and Persistent Free Radicals in the Volatiles during Pyrolysis of Lignocellulose Biomass. *Environmental Science & Technology*, 54(20), 13274-13281. <https://doi.org/10.1021/acs.est.0c03363>
- Zhu, X., Han, Y., Feng, Y., Cheng, P., Peng, Y., Wang, J., Cai, J., & Chen, Y. (2022). Formation and emission characteristics of intermediate volatile organic compounds (IVOCs) from the combustion of biomass and their cellulose, hemicellulose, and lignin. *Atmospheric Environment*, 286, 119217. <https://doi.org/https://doi.org/10.1016/j.atmosenv.2022.119217>