Smoke Risk to Vineyards from Prescribed Grassland Fires
Impacts of distance and natural barriers

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Background.

Fire is a perpetual risk factor in the production of perennial crops in the western agricultural regions of the United States. Concerns with fire range from direct damage due to combustion to residual effects of smoke exposure. In the winegrape vineyards of northern California, fire and its associated smoke pose a unique threat in the form of smoke-taint damage to the fruit. Smoke-taint is an emerging characteristic that occurs when the volatile phenols (VPs) released from the burning of lignocellulose, bind to compounds in the skin and pulp of grape berries to form phenolic diglycosides (PDs) (Crews et al., 2022; Krstic et al., 2015). Phenolic diglycosides often require the introduction of an enzyme to separate from the compound it is bound to; these enzymes may be highly specific to the type of PD in question (Crews et al., 2022). The phenols typically used to indicate smoke taint in must or wine are guaiacol and 4-methyl guaiacol with a handful of other phenols often measured as well (Caffrey et al., 2019; Modesti et al., 2021). Because of the unique requirements to break these bonds, PDs can make it through the winemaking process and not be noticed until enzymes in our mouths separate them out, allowing them to re-volatilize. VPs may also bind with plant sugar compounds with an affinity for binding with phenolic compounds making the resulting smoke-taint a significant problem in grape berries with high sugar content. Common phenolic binding

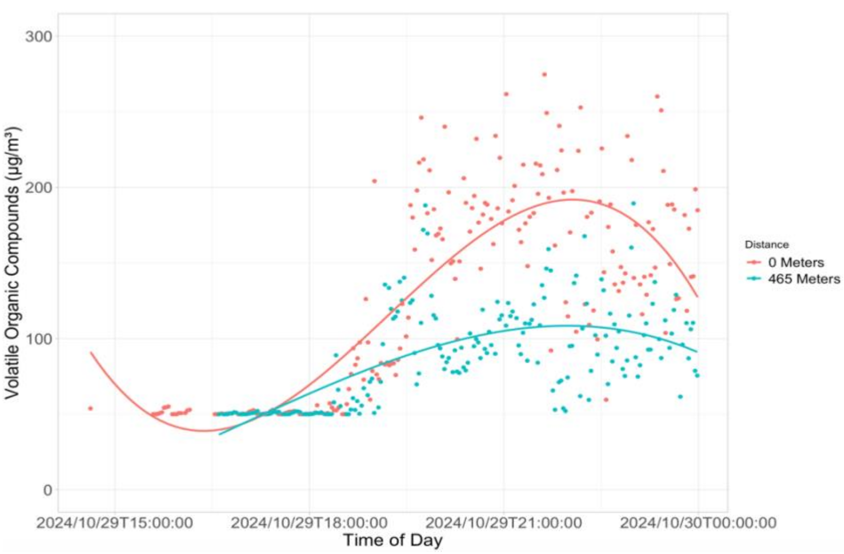

Figure 1. Volatile Organic Compounds (VOCs) quantified at two distances (0m and 465m) from the source of a prescribed burn; fuel loads were predominately grass and forb species.

sugars include glucose, fructose, and others can be found in fruit and resulting wine (Bönisch et al., 2014; Caffrey et al., 2019).

Considerable effort has been put into the examination of volatile phenols and the factors that impact their production. The fuel material burned in the fire affect the amount of VPs released during that fire (Chira & Teissedre, 2013). Grasses have a notably lower lignocellulose content when compared with hardwood, perennial trees; this results in fewer VPs released during grass fires than in forest fires (Krstic et al., 2015; Simoneit, 2002). This information is valuable as we look at the use of prescribed fire to help reduce the risk of wildfires in California. A large percentage of the prescribed fires conducted in the state are primarily focused on burning grassy areas and may pose a lower smoke-taint risk to winegrapes than a forest fire where large perennial species burn. However, little research has been conducted to examine this phenomenon.

Methods.

Prescribed burning at the University of California, Hopland Research and Extension Center (HREC) occurs annually for the purposes of fire safety and to accommodate research studies within the property bounds. HREC is also surrounded by many winegrape vineyards which may or may not be at risk of crop damage as a result of the prescribed burns conducted at the station. A preliminary study was conducted in 2024 to quantify the risk of smoke-taint from these prescribed burns through measurements of volatile organic compounds (VOCs) released during the burns. PurpleAir Flex sensors were installed to measure the VPs released; one was placed at the source of the fire, and another was placed 465 meters from the source of the fire and behind a stand of conifers. Placement of the further sensor was decided due to the ability of leaves to bind to volatile phenols produced during smoke-events (Krstic et al., 2015). The sensors used were unable to distinguish VPs from other volatile organic compounds but include VPs in the observed data. Data was collected via the PurpleAir Flex sensors beginning three hours before and throughout the burn window during any period of active smoke production.

Results.

Through preliminary data collection, these data show a distinct decline in airborne VOC concentrations when comparing values at the source of smoke and at 465 meters away from the source of smoke. The variable of distance when measured was statistically significant and much lower when comparing the further sensor readings to the point-source readings with a p-value < 0.001 and Tukey honest significant differences present between these factors. On average, the concentrations of VOCs measured were 31% lower in the further sensor than the close sensor during the period where smoke was being released from the prescribed burn (18:00 h to 23:00 h); this represents an average 40 $\mu g/m^3$ decrease in airborne VOC concentrations at the more distant measurement point. These data are indicative of a reduction in airborne VOCs due to both distance and foliar barriers that may absorb the volatile compounds as they move through the canopy.

Conclusion.

This preliminary study represents the potential for further research into the effects of smoke from prescribed burning on nearby agricultural systems. The data collected from this single burn event required a minimal investment and time commitment; it serves to lay the foundation for elucidating the real impacts of grass-fueled, planned burns on various crops susceptible to smoke-taint damage. Through the use of two sensors and proper planning, this study has identified an average reduction in airborne volatile organic compounds of 31% within less than 500m of the smoke source point. Further work is called for to verify these findings and to account for the influence of a foliar canopy acting as a barrier between the source of smoke and the potential cropping system at risk of smoke damage. Investigations going forward should delineate the influence of distance from smoke source and foliar barriers when designing studies to assess risk of smoke damage from prescribed, grassland burns.

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