Air Quality Monitoring and the Safety of Farmworkers in Wildfire Mandatory Evacuation Zones

Carlo A. Chunga Pizarro*, Rebecca R. Buchholz**, Rebecca S. Hornbrook**, Michael Méndez*
*University of California at Irvine, Department of Urban Planning & Public Policy **NSF National Center for Atmospheric Research

Background & Purpose

Wildfire frequency and intensity, as well as the impacts of wildfire smoke, are predicted to increase with global warming and drier conditions in the future (1,2). In 2020, California experienced an unprecedented number of wildfires, with 44% (22 fires) of the 50 largest fires in the U.S. occurring in the state (3–5). The disastrous wildfire season exposed more than half of California's population to the highest number of severe air pollution days in the state's recorded history (6). The California Fourth Climate Assessment report projects that the state's wildfire burn area may increase 77% by the end of the century (7). Extreme wildfire events and environmental justice concerns intersect in Northern California's Sonoma County. The county has experienced severe air pollution and loss of life and property from wildfires, particularly during periods of drought and extreme heat (8). Moreover, Sonoma's economy heavily relies on livestock, agriculture, and the region's award-winning wine. The winegrape sector alone employs more than 70% (or 8,500) of the laborers in the county (9). However, the total number of farmworkers may be significantly undercounted due to the large undocumented workforce, which often avoids interaction with governmental representatives for fear of deportation (10).

This study explores the health and safety implications of the Ag Pass program, a program that allows farmworkers to enter mandatory wildfire evacuation zones to perform agricultural labor under hazardous conditions. Specifically, we compare PM2.5 data collected during the 2020 wildfire season from the EPA's AirNow monitor and the network of low-cost PurpleAir monitors in Sonoma County. The study focuses on two major wildfire events, the LNU Lightning Complex and the Glass Fire, to assess the accuracy of existing air quality monitoring systems and to highlight structural inequalities faced by farmworkers during wildfires. Based on these findings, we provide policy recommendations to enhance protections for farmworkers, with an emphasis on undocumented and vulnerable populations.

Research Questions

1. How does wildfire smoke exposure impact farmworkers in Ag Pass regions, particularly in terms of health risks and safety concerns during mandatory evacuation zones?
2. How does the PM2.5 data from the network of PurpleAir monitors compare to data from the regulatory AirNow monitor in assessing air quality in Sonoma County during wildfire events?

Article & Policy Briefs

Policy Brief (2022): Addressing disparities in Sonoma County's Agriculture Pass program

Policy Brief (2024): Local Air Quality Monitoring During Wildfire Events

Geohealth (2024): Academic article

Materials & Methods

Ag Pass Records

We obtained Ag Pass permit applications issued in Sonoma County during 2020 through a public records request. Applications and associated data were reviewed for consistency and mapped using ArcGIS. Only permits with complete address locations were included, resulting in 370 permits mapped for LNU Complex (590 worksites, 1,603 workers) and 96 permits for the Glass Fire (120 worksites, 633 workers). Data limitation included incomplete worksite information and inconsistent worker count.

AirNow PM2.5 Data

PM2.5 data from Sebastopol AirNow monitor (July 31- November 6, 2020) were downloaded and filtered to include daily averages with ≥90% data coverage. These data were used as a benchmark for air quality in the region.

PurpleAir PM2.5 Data

We analyzed raw PurpleAir PM2.5 data from 359 monitors in Sonoma County for the same time period. Data was filtered for reliability, removing hourly values with significant discrepancies between dual sensors. The EPA-recommended smoke correction was applied to adjust for wildfire conditions. Data with ≥90% daily coverage were used to calculate hourly and 24-hour average.

Wildfire Pollution

We identified 3 wildfire pollution events during the study period: (a) LNU1 (August 19-31), (b) LNU2 (September 8-15), and (c) Glass (September 27-October 5). Events were defined by PM2.5 levels exceeding 30 µg m3. For each event, we analyzed daytime and nighttime maximum PM2.5 values using AirNow and aggregate PurpleAir data in farmworker Ag Pass regions.

Results

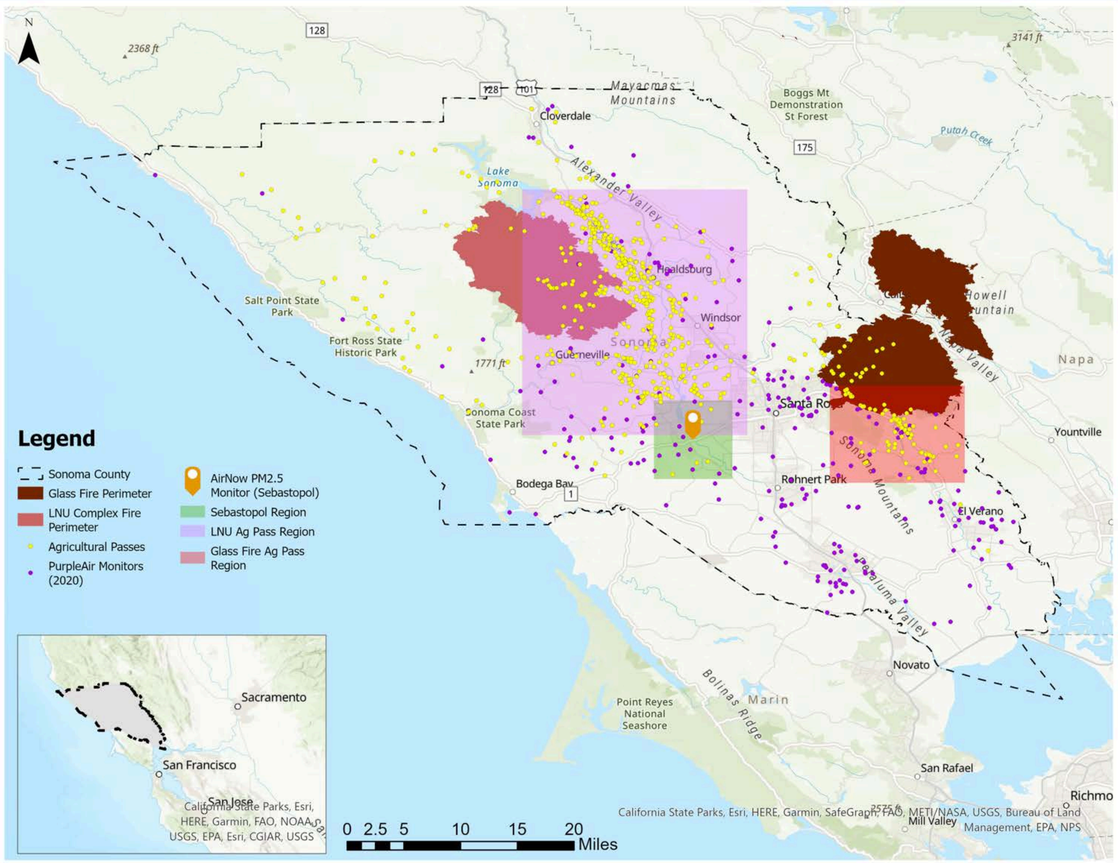

Figure 1: Map of Sonoma County showing the county perimeter, the Sebastopol AirNow monitor, PurpleAir monitors, fire perimeters for the LNU Complex and Glass Fire, and locations of Ag Passes issued during these fires. Shaded boxes highlight the LNU Complex Ag Pass region (purple), Glass Fire Ag Pass region (red), and Sebastopol region (green). The inset shows Sonoma County's location in California.

PM2.5 Variability During the 2020 Wildfire Season

The analysis revealed significant differences between PM2.5 measurements from AirNow and PurpleAir monitors in Sonoma County during the 2020 wildfire season. AirNow data underestimated smoke exposure compared to the PurpleAir network, which captured greater spatial variability and provided more detailed insights into localized pollution. Figure 1 highlights the distribution of 359 PurpleAir monitors across Sonoma County compared to the single Sebastopol AirNow station. The map illustrates how PurpleAir monitors provided granular data coverage in key wildfire-affected regions, including the LNU Complex and Glass Fire zones. PurpleAir monitors indicated that 24-hour PM2.5 levels exceeded the World Health Organization (WHO) guideline (>15 µg/m³) on 34 days, whereas AirNow reported exceedances on only 18 days. Similarly, PurpleAir data showed PM2.5 levels surpassing the EPA's "Unhealthy" threshold (>55.5 µg/m³) on 16 days, compared to 13 days reported by AirNow.

Acknowledgments

This material is based upon work supported by the NSF National Center for Atmospheric Research, which is a major facility sponsored by the U.S. National Science Foundation under Cooperative Agreement No. 1852977. The project upon which this article is based was funded through the NSF NCAR Early Career Faculty Innovator Program under the same Cooperative Agreement and the Andrew Carnegie Corporation grant.

Citations

Results cont.

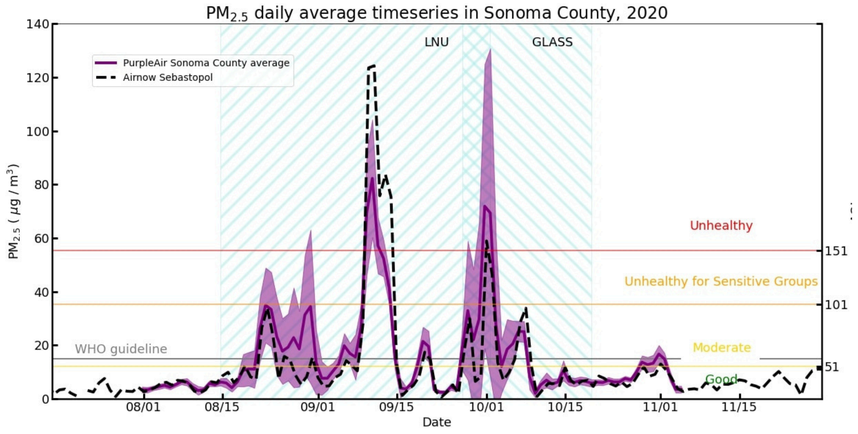

Figure 2: Time series of 24-hour PM2.5 values from the Sebastopol AirNow monitor (black, dashed) and the county-wide average of smoke-corrected PurpleAir PM2.5 (purple) with spatial standard deviation (shaded purple). WHO's 24-hour PM2.5 guideline (15 µg/m³) and EPA health thresholds are shown as horizontal lines. Time periods for the LNU and Glass fire complexes are marked with light blue hatched shading.

Impacts on Farmworkers in Ag Pass Regions

Farmworker regions experienced significantly higher PM2.5 levels than those recorded by the Sebastopol AirNow monitor. During the Glass Fire, PurpleAir data indicated PM2.5 concentrations in Ag Pass zones that were three times higher than AirNow estimates, revealing the inadequacy of the regulatory monitor in representing localized air quality. Figure 2 demonstrates the temporal evolution of 24-hour PM2.5 levels, showing how PurpleAir monitors consistently recorded higher and more variable PM2.5 levels than the AirNow monitor, especially in Ag Pass regions. Furthermore, nighttime PM2.5 levels in these regions often exceeded daytime levels, particularly during the Glass Fire, posing heightened health risks for workers harvesting overnight.

These findings demonstrate that AirNow data does not sufficiently capture localized air quality variations, leading to underestimations of smoke exposure in wildfire-prone areas. PurpleAir monitors, with their ability to reflect regional disparities, are essential tools for assessing workplace safety and ensuring farmworkers' health is adequately protected in Ag Pass zones. The spatial and temporal insights provided by PurpleAir data emphasize the need for enhanced monitoring systems in wildfire-affected agricultural areas.

Policy Implications & Conclusion

The Ag Pass program aims to safeguard agricultural operations but has raised serious health concerns for farmworkers. Our analysis highlights these risks and we suggest the following actions that state and local governments should take before, during, and after wildfires to protect farmworkers in evacuation zones. The growing frequency and severity of wildfires make it imperative to monitor the program's impacts and further explore its effects on farmworker safety:

1. **Mandatory Employer Emergency Plans and Training**
2. **Clear Protocols for Worker and Site Identification**
3. **Real-Time Air Quality Monitoring**
4. **Hazard Pay**
5. **Post-Exposure Health Screenings**
6. **Post-Incident Accountability**

These measures address critical health and safety gaps in the Ag Pass system and aim to protect vulnerable farmworkers in wildfire-prone regions. Further research and monitoring are essential as wildfires continue to intensify. Integrating real-time air quality data with robust emergency protocols can improve outcomes for farmworkers and reduce preventable health impacts. By prioritizing the well-being of agricultural workers, policymakers can align disaster response efforts with principles of equity and environmental justice.