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Mapping Climate Vulnerability and Air Pollution in Contra Costa County: Identifying Hot Spots and Targeting Interventions

Factsheet

January 2026

Contra Costa residents are experiencing growing climate-change related impacts like extreme heat alongside persistent air quality issues from energy, industry, and transportation-related pollution. These impacts add to the disproportionate environmental, institutional, and social burdens many residents already face. While government and community-based organizations are working to address these issues, persistent data gaps complicate the designing, targeting, and implementing of interventions. Notably, local trends in air quality, particularly for overburdened communities, are not captured by the Bay Area Air Quality Management District's (BAAQMD) three fine particulate matter ($PM_{2.5}$) monitors.

What is $PM_{2.5}$ and why is it important?

$PM_{2.5}$ is a mixture of small suspended particles produced from sources like fossil fuel combustion, industrial activity, gas-powered cars, and wildfire smoke. High levels of $PM_{2.5}$ exposure have been associated with premature mortality and numerous adverse cardiovascular, respiratory, and pregnancy outcomes.[1]

To protect public health and welfare, the US Environmental Protection Agency (EPA) has set regulatory standards for this pollutant[2], which have become stricter over time as our understanding of its health risks have grown.[3] While we used these standards as helpful benchmarks for our study, only regulatory-grade monitors can be used to determine violations.

This study identified opportunities to mitigate the public health impacts of these exposures. First, we addressed the air monitoring gap by collaborating with community partners to deploy a network of 50 low-cost Aeroqual

1 (Guo et al., 2014) (EPA, 2025c)
2 Environmental Protection Agency (EPA, 2025b). NAAQS Table. https://www.epa.gov/criteria-air-pollutants/naaqs-table
3 Environmental Protection Agency (EPA, 2025). Integrated Science Assessment (ISA) for Particulate Matter. https://www.epa.gov/isa/integrated-science-assessment-isa-particulate-matter

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sensors in historically under-monitored communities. We combined these data with data from 700 privately-owned PurpleAir sensors and calibrated the reported measurements to identify neighborhood-level trends in $PM_{2.5}$ pollution from September 2023 through May 2025 (**Figure A**). We then estimated exposure to extreme heat using satellite data from NASA[4] and assessed where residents may face combined air quality and extreme heat exposures.

Our next step was to show the unique challenges different communities face by identifying hot spots where these environmental exposures overlap with population sensitivities and low adaptive capacities to form specific climate vulnerabilities. Lastly, we conducted a review of possible interventions (including policies, household changes, and community efforts) and examined them through the lens of community members and implementability by holding a community listening session.

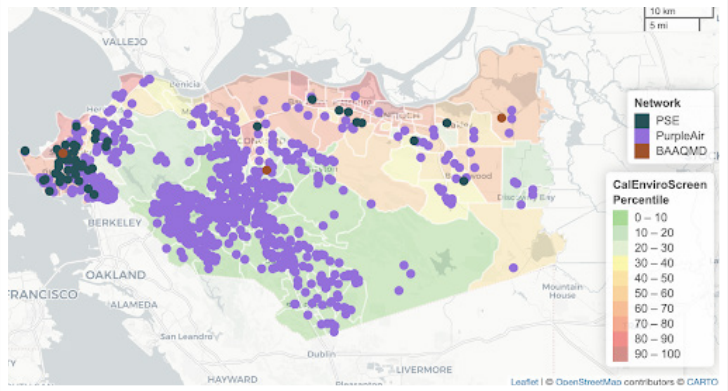


Figure A: Air Quality Monitoring Network in Contra Costa County. PurpleAir monitors, managed independently from this study, offer more insight into local air pollution concentrations than the BAAQMD sensors can provide but are concentrated in affluent areas.[5] PSE's Aeroqual monitors were strategically deployed in areas with high CalEnviroScreen scores and minimal existing monitor coverage and were hosted by volunteers at homes, public schools, a fire department, and a BAAQMD monitoring site. Data from the three regulatory-grade BAAQMD $PM_{2.5}$ monitors were not included, though their locations are shown for reference.

What is climate vulnerability and why is it important?

Climate vulnerability identifies where, due to a confluence of factors, people may suffer worse health impacts from climate change and should be considered for prioritized intervention planning. The California Department of Public Health's climate vulnerability framework[6] considers three core contributing factors:

1. *Environmental exposures* (e.g. hazardous conditions such as high concentrations of air pollution or extreme heat),
2. *Population sensitivities* (factors that exacerbate the impacts of environmental exposures such as older age or certain occupations; poverty increases sensitivity)
3. *Adaptive capacity* (infrastructure and resources that can mitigate the impacts, such as tree canopy coverage or air conditioning; poverty also reduces adaptive capacity).

Key Findings

Air Quality and Extreme Heat

We identified air pollution hot spots in Richmond, San Pablo, Antioch, Oakley, and Pittsburg, including long-term $PM_{2.5}$ concentrations around 8-9 micrograms per cubic meter ($\mu g/m^3$) (**Figure C**). While just below the US EPA standard[7] of 9 $\mu g/m^3$, this level of pollution may still pose a health risk based on studies showing the harmful effects of long-term exposure to even low levels of $PM_{2.5}$.[8] Richmond, Martinez, and Pittsburg experienced the most frequent episodes of acute air pollution.

We used Contra Costa County's five supervisorial districts to organize regional analysis at a scale useful

4 Thornton, M. M., Shrestha, R., Wei, Y., Thornton, P. E., & Kao, S.-C. (2020). Daymet: Daily Surface Weather Data on a 1-km Grid for North America, Version 4 [Dataset]. ORNL DAAC. https://doi.org/10.3334/ORNLDAAC/1840
5 (Liang et al., 2021) (Desouza & Kinney, 2021)
6 California Department of Public Health (CDPH, 2023). Climate Change and Health Vulnerability Indicators for California. https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx
7 Environmental Protection Agency (EPA, 2025b). NAAQS Table. https://www.epa.gov/criteria-air-pollutants/naaqs-table
8 Liu, J., Varghese, B. M., Hansen, A., Zhang, Y., Driscoll, T., Morgan, G., ... & Bi, P. (2022). Heat exposure and cardiovascular health outcomes: a systematic review and meta-analysis. The Lancet Planetary Health, 6(6), e484-e495.

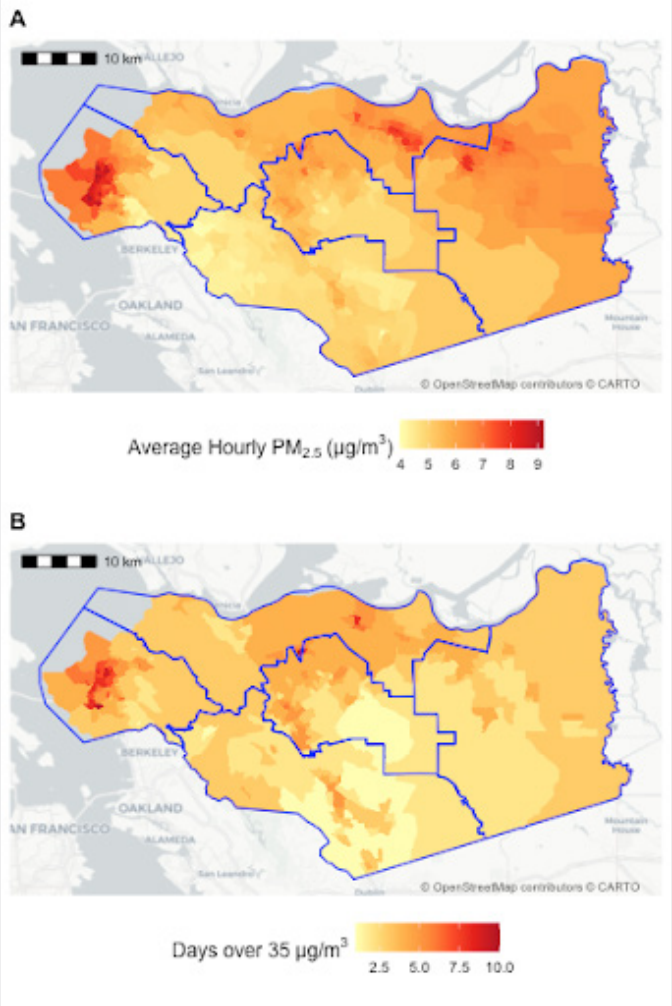
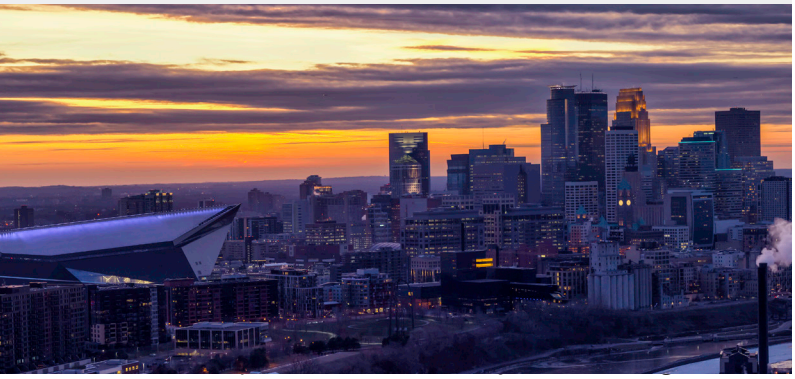


Figure C. Fine Particulate Matter ($PM_{2.5}$) concentrations across Contra Costa County, September 2023 – May 2025. Panel A illustrates the average hourly concentrations across the study period at the census block group. Panel B illustrates the number of days with 24-hour mean $PM_{2.5}$ concentrations above 35 µg/m³, the US EPA NAAQS for daily $PM_{2.5}$ concentrations, for each block group. Panel B illustrated the Blue lines represent supervisorial district boundaries. A single day's concentration above the threshold does not represent a violation because violations are assessed over a three year period using regulatory-grade monitors.



concentrations overall were higher in Districts 1 (West) and 5 (North) that have a number of polluters (oil refineries, power plants, industrial activity) and heavy vehicle traffic, as well as District 3 (East) which experiences high temperatures that can trap and amplify air pollution in the area.

Our findings show how dense local monitoring with low-cost sensors can illuminate the unique hazard exposures and exposure trends within a community, offering a more detailed picture than dispersed regulatory monitors.

Extreme heat exposures followed an east-west gradient, with the most frequent extreme heat events in District 3 (East). Contra Costa's northeastern communities then faced the greatest dual exposure to air pollution and extreme heat. Evidence also suggested that Black and Hispanic populations, as well as outdoor workers and children under the age of five, experienced higher average air pollution levels and more extreme heat events than other demographic groups. Furthermore, people living under 200 percent of the Federal Poverty Level experienced slightly higher air pollution levels. Demographic differences are likely driven by nearby pollution sources like industrial sites and heavily-trafficked roads.

Climate Vulnerability and Targeting Interventions

Communities across Contra Costa have different overlapping exposures, population sensitivities, and adaptive capacities (see **Figure D** as an example of overlapping air pollution, poverty, and outdoor worker residence).

To be most effective, interventions can also be designed to target each community's specific combination of challenges, accounting for local resources and limitations. For example, residents in southern Richmond and Antioch face relatively high pollution levels, but given high poverty rates in those same areas, households may need financial support to purchase, run, and maintain air purifiers to mitigate this exposure.

At the same time, community-scale interventions such

as reducing local emission sources could help alleviate air pollution regardless of household wealth and protect outdoor workers who have less control over their outdoor exposures.

We identified a set of key factors to consider when designing interventions to address overlapping clusters of exposure, sensitivity, and adaptive capacity. These included who can implement a given intervention, what barriers they may face, and the intervention's mechanism, breadth of potential benefits, and alignment with other local, regional, or state goals. Effective and equitable implementation of household-level interventions such as running air conditioning require particular support to overcome barriers such as financial burden and lack of knowledge of existing programs. **When designing interventions, it is critical for planners and policymakers to understand and account for each community's context—their exposures, population sensitivities, adaptive capacities, and barriers.**

Looking Ahead

Our findings can inform new efforts and modification of current efforts to protect vulnerable populations from climate- and pollution-related exposures in Contra Costa County. Both governmental and non-governmental organizations across Contra Costa and the state have programs in place to support interventions that can address these exposures—for example, the county's climate action and adaptation plans include some of the interventions identified in our review.

To better understand and address environmental and climate vulnerabilities, we recommend that stakeholders, planners, and policymakers:

- Analyze additional exposures, population sensitivities, and adaptive capacities such as flooding, pre-existing health conditions, and language barriers. This includes how extreme weather events impact both neighborhoods and the transportation, energy, and water networks that support them
- Develop and maintain a low-cost sensor network, especially in East Contra Costa, to help fill in the air quality monitoring gaps
- Continue considering how interventions can be designed to mitigate multiple exposures and vulnerabilities
- Undertake targeted, localized community engagement to understand what interventions would best fit a community's needs and what lines of communication and support are necessary to ensure residents are both aware of and can access these targeted interventions.

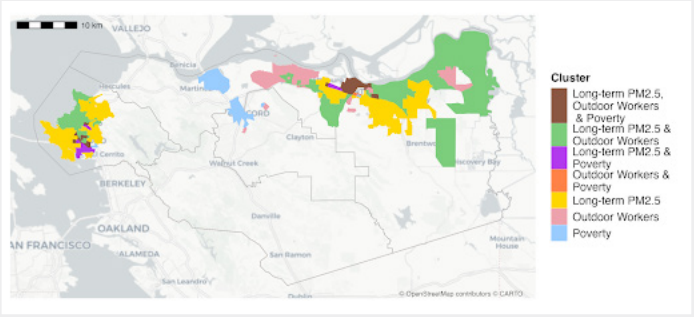


Figure D. Overlap of exposure, sensitivity, and adaptive capacity across Contra Costa. Clusters of census block groups with high levels of $PM_{2.5}$ exposure as well as high concentrations of sensitive populations (outdoor workers) and low adaptive capacity (represented by poverty).

For further information on this work, see the Mapping Climate Vulnerability and Air Pollution in Contra Costa County: Identifying Hot Spots and Targeting Interventions full report.