The Exposure of Disadvantaged Underserved Communities to Pesticides in the San Joaquin and Tuolumne Watersheds (Central Valley, CA)

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Abstract
The San Joaquin Valley is one of the most productive agricultural regions in the world. Intensive agricultural activity includes the regular application of chemical pesticides, often in close proximity to communities, especially unincorporated and Disadvantaged Underserved Communities (DUC). This study examines the spatial distribution of pesticide application and its proximity to DUCs in the San Joaquin and Tuolumne watersheds in the Central Valley, CA. This work is done in collaboration with our partners at the Tuolumne River Trust, Modesto Office. We are mapping crops and pesticide loads and estimate the average pesticide ranking for four different urbanized settings. The results generated indicate that DUCs and unincorporated areas are currently experiencing the highest pesticide applications, with unincorporated DUCs, on average, close to the 70% percentile in statewide pesticide application rates, and incorporated DUCs at 50%. Planned work will explore the feasibility of mapping the relationship between pesticide application amount and crop type on the field scale, and identifying priority areas for pesticide use reduction in vulnerable communities.

Introduction
The area of interest is three watersheds in central California: Tuolumne, lower San Joaquin, and the San Joaquin Delta. This area covers part of the highly agriculturally productive Central Valley. The objective of the study is to use GIS to identify communities that are most at risk of pesticide exposure. To do this, we will examine pesticide application in disadvantaged underserved communities (DUCs), and in unincorporated areas.

The definition and location of DUCs used here is from CalEnviroScreen 3.0. A score is calculated from 20 statewide characteristics of exposure to pesticides and pollution and population characteristics that make people more vulnerable to pollution. Communities with scores in the top 25 percentile are considered disadvantaged and underserved.

Additionally, we will consider unincorporated places. These are settled areas outside of city limits that often rely on well water rather than treated city water, making them more vulnerable to consuming water contaminated with pesticides.

Results
Fig. 2: Disadvantaged underserved communities (DUCs), classified by CalEnviroScreen, are shown alongside other designated urbanized places. Areas outside the bold incorporated lines are unincorporated.

Fig. 3 shows that places that are disadvantaged and underserved as well as unincorporated are indeed receiving the highest pesticide loadings.

Fig. 4: Section scale pesticide data, not covering the lower portion of the map. Third and fourth quartile are shown as hollow squares, and their intersections with unincorporated DUCs are filled in. Data from CalPIP 2018.

Higher resolution pesticide data was used in Fig. 4 to identify these most vulnerable communities more specifically. Most of them were just outside the limits of larger cities such as Stockton and Modesto.

Fig. 5: Cropland data layer identifying crop type from satellite data with 30 m resolution. The 20 most common crops in the study area are shown in the legend, from most to least area. Data from USDA, 2018.

Data and Methods
- Data processing was performed in R. Mapping and analysis was performed in QGIS.
- The disadvantaged underserved communities (DUC) layer is from CalEnviroScreen 3.0, which gives communities a score based on pollution exposure and characteristics that may make a community more vulnerable, including a percentile of each census tract for pesticide application.
- Two layers were differenced to isolate unincorporated places: California incorporated cities, and all places (incorporated and unincorporated).
- Higher resolution pesticide data was available from CalPIP. The pounds of active ingredient applied were summed for each section, then linked to the PLSS layer so that they could be mapped. Data was not available for every section in the study extent.
- The pesticide percentile for each census tract was extracted and averaged over each of the four types of urbanized regions (incorporated/unincorporated, DUC/not DUC). DUCs with the highest average pesticide loading score were identified.

Conclusions and Outlook
- Unincorporated and incorporated communities (DUCs) are exposed to significantly higher amounts of pesticide applications, on average, than non-DUCs. Thus, communities that are most vulnerable to negative consequences of pesticide exposure are also the most exposed. DUCs with the highest pesticide loads were identified as priority areas for pesticide load reduction.
- Pesticide applications in unincorporated areas are particularly worrisome, as there is likely exposure through air and water, as people in unincorporated areas are mostly not connected to water systems and draw from private wells.
- We will examine which crops close to unincorporated DUCs receive the most pesticide application, and what viable alternatives can be recommended.
- We are also working on a higher spatial resolution dataset of pesticide application, potentially by expanding the area and information contained in the CalPIP and PLSS dataset.

Citations
Data: CA county boundaries (US Bureau of Reclamation), National Hydrography Dataset (rivers and lakes, USGS), Watershed boundary dataset (CA Natural Resources Agency), CalEnviroScreen 3.0 (DUCs, CA Office of Environmental Health and Hazard Assessment, 2018), CA incorporated cities (CA Board of Equalization), TIGER (places, US Census Bureau 2020), Public Land Survey System (PLSS, Bureau of Land Management); CA Pesticide Information Portal (CalPIP, 2018, CA Dept. of Pesticide Regulation); Cropland data layer (US Dept. of Agriculture, 2018). Software: QGIS Geographic Information System (QGIS Association, 2021); R (R Core Team, 2020), stringr package (Hadley Wickam, 2019).
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