Exploring Spatial Relationships and Environmental Justice in San Francisco?

Analysis Background and Context:

San Francisco ranks 8th among the most expensive cities in the world according to the research and analysis division of *The Economist* newspaper (Garcia, 2022). High incomes from the booming tech industry and a limited housing supply have increased housing prices in San Francisco. The supply and demand constraints on the housing market allow property owners to increase rent and make the cost of living highly unaffordable. The average home price in the city is $1.4 million, and the average rent is $3,600 (Zillow, 2022). Due to this high cost, many people are pushed into housing insecurity. Middle and lower income residents risk eviction, homelessness, and are required to spend a disproportionate percentage of their income on rent. Using spatial analysis as a framework, we may understand how to improve housing security in San Francisco while navigating environmental justice issues around access to clean air and parklands. I chose to look at the current locations of affordable housing and identify areas where affordable housing organizations could convert vacant properties into new affordable units.

I did all my analysis through the lens of accessibility to public green spaces and urban trees. Accessibility to parks and urban tree coverage is essential for public health. A study found that the distance to a park is significantly related to the quality of one's mental health. Researchers found that "residents within short walking distance from the park, within 400m," had the best quality of mental health and mental health decreased substantially at further distances (Sturm, 2019, p. 19). Grote (2016) studied the pollution mitigation effect of urban trees in European cities. The paper explores how high tree density captures pollutants due to more leaf surfaces undergoing chemical reactions (Grote, 2016, p. 545). Both studies show empirical evidence that housing location impacts the residents' mental health and exposure to higher pollution levels. Exposure to particulate matter results in health effects such as lung and heart disease (EPA, 2022).

Data:

I used six datasets throughout my project. Three of the datasets I used came from the San Francisco government webpage. The first dataset covered all affordable rental housing locations in San Francisco. The city government collected the dataset by tracking the investments into affordable housing made by the Mayor's Office of Housing and Community Development (MOHCD, 2022). The data were represented as point files and only changed the symbology (DataSF).

I also downloaded an excel file showing vacancy locations in San Francisco. I joined this dataset to a shapefile containing the city's census tracts. After this processing, I could show the top ten most vacant census tracts in San Francisco. I also downloaded a shapefile containing the San Francisco public parks from SF.gov's database (DataSF). I used this data to show the spacial relativity of existing affordable housing to public green spaces. I also analyzed the proximity of public parks to census tracts with high vacancy rates. I processed this data into a Euclidean Distance raster that showed a graduated distance from each park.

From the class drive, I pulled census data and the CalEnviroscreen data. I used a query on both of these datasets to only show data contained within the City of San Francisco. I then used CalEnviroscreen to show a graduated map of diesel particulate matter across San Francisco. I used Jenks Natural Breaks on the pollution dataset with five breaks. I joined the census data with the vacancy data to spatially show the most vacant census tracts (CalEnviroscreen).

Since I wanted to study tree coverage in San Francisco, I used the California Forest Observatory website to download a shapefile that contained all of the tree coverage in San

Francisco. I then joined the tree coverage data to the census tract shapefile and added a new field that calculated the percentage area covered by trees in a given census tract. I processed this further by using Jenks Natural Breaks to show graduated colors where the tree density was highest vs. lowest (California Forest Observatory).

Methods:

1. Import spatial data for San Francisco.
2. Identify the distance to parks from affordable housing.
3. Identify areas of high and low tree coverage.
4. Identify areas of high pollution in the city.
5. Identify the top 10 most vacant census tracts in San Francisco.
6. Use Fuzzy Logic to determine the most suitable locations for new affordable housing based on criteria of having high tree density, high vacancies, relative closeness to parks, and being further from areas of high pollution.

(Canales, 2020, March 6)

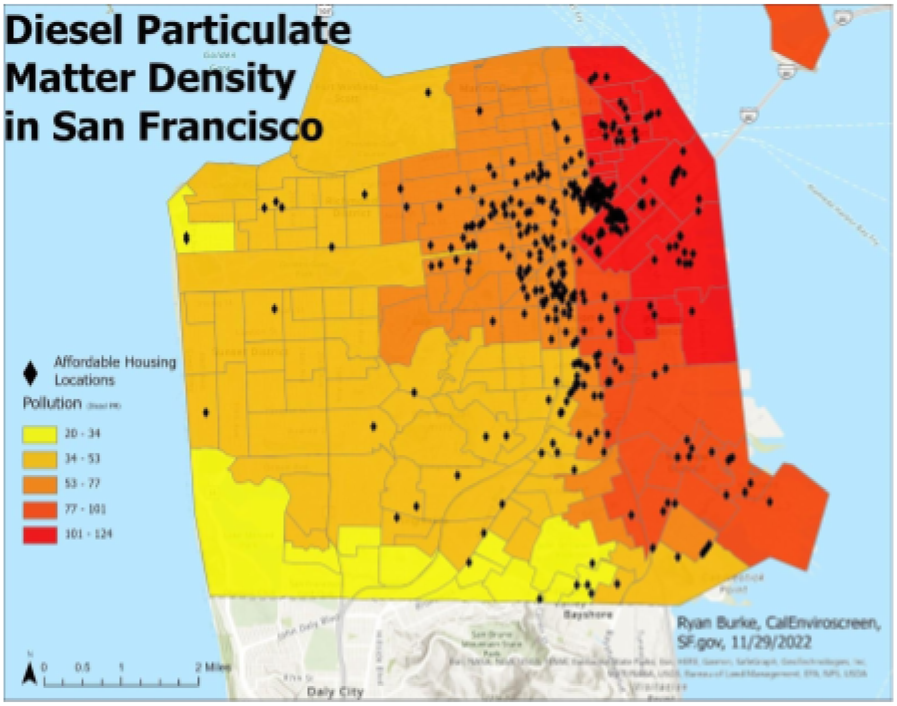

Figure 1 | Diesel Particulate Matter Density in San Francisco

Results:

Before my project, I hypothesized that affordable housing would be located in less desirable locations due to housing costs including externalities such as clean air, access to parks, and tree coverage in their price. Upon reviewing my maps and datasets, we see that this holds. For example, in Figure 1, the highest concentration of diesel particulate matter is concentrated on the west side of San Francisco, and many of the affordable housing units are located in these areas of medium to high pollution. Figure 2 shows the distribution of tree coverage across the city. The darker areas represent more trees, and the black shapes are outlines of actual trees in San Francisco. One takeaway from Figure 2 is that the larger the park, the more tree density there seems to be. Figure 3 expands on Figure 2 and shows the percentage of tree coverage per census tract represented by graduated colors and the locations of affordable housing represented by points. The least dense tree coverage is the lightest gradient, and by zooming in on the downtown area of San Francisco, much of the affordable housing is located in these areas of low tree density.

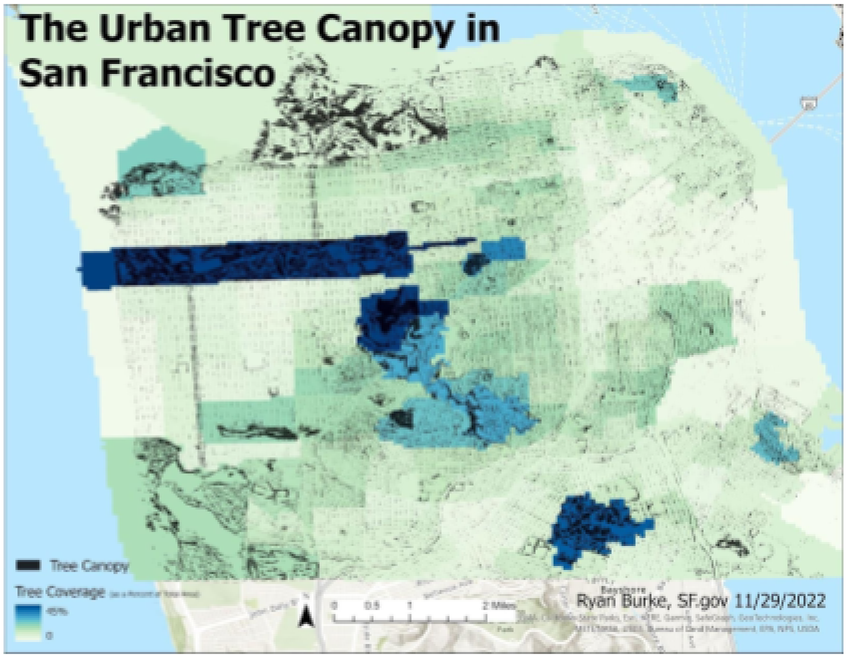

Figure 2 | The Urban Tree Canopy in San Francisco

From the research mentioned earlier, we understand that particulate matter impacts health, and tree density mitigates urban particulate matter. The combination of high pollution and low urban tree density can negatively affect micro-regions within the city. In Figures 1-3, we can see that most affordable housing locations fit into this classification of more exposure to air pollution.

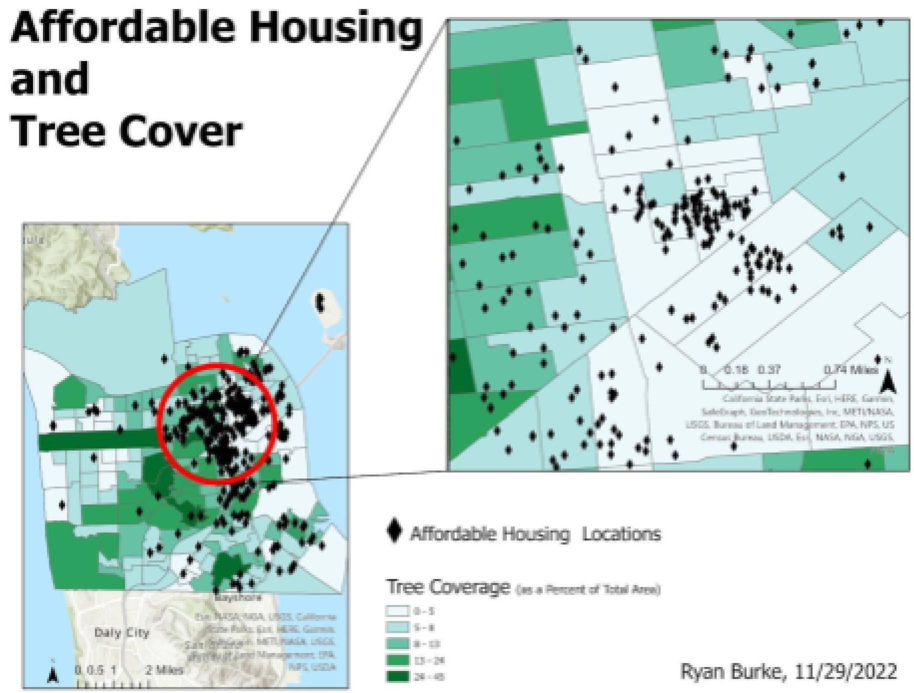

Figure 3 | Affordable Housing and Tree Cover

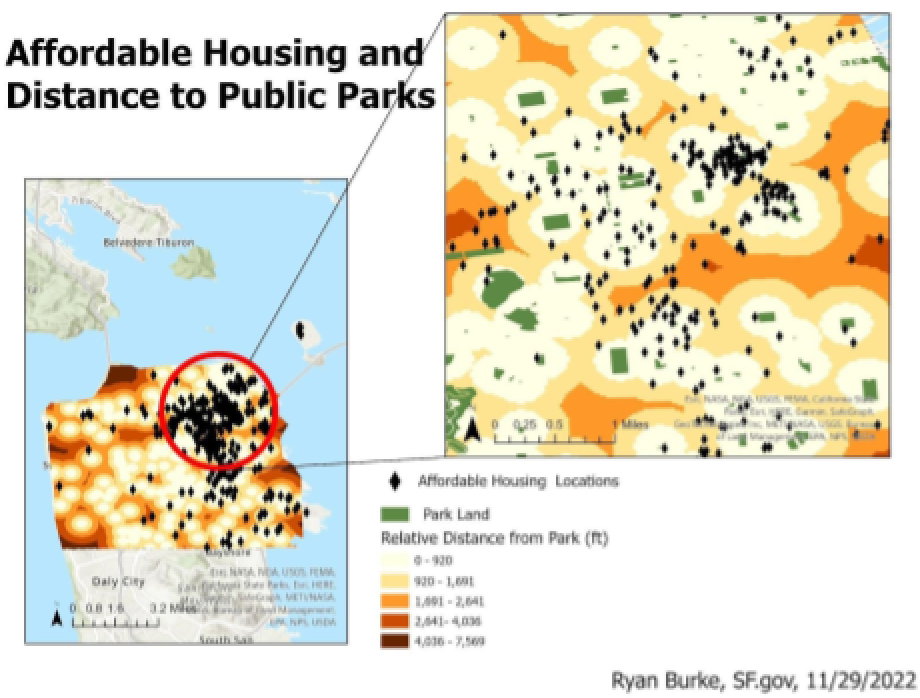

Figure 4 | Affordable Housing and Distance to Public Parks

Figure 4 represents the distribution of parks relative to affordable housing locations. Focusing on the high concentration of affordable housing, we see many units fall within 1,691 feet or 515 meters of public green space. These distances are reasonable because many units are within 400m of parks, which is crucial for mental health (Sturm, 2019, p. 19). The only critique of this spatial analysis is the size of some of these public spaces seems small (< 0.01 miles). Further research should be done to understand how the size of parks affects public health.

Figure 5 | Where to look for new Affordable Housing

Figure 5 shows my top three areas to look into when converting vacant properties into affordable housing. The blue census tracts are the ten most vacant tracts with > 300 units. The red bubbles show the parks in the area. I used fuzzy logic to determine the most suitable locations. Using my subjective inference, I assigned a fuzzy weight to the variables: closeness to parks, urban tree coverage, and pollution levels. Overall trends from previous figures show that larger parks have higher tree density and that more particulate matter congregates on the city's western side. With this in mind, the first choice in new locations for affordable housing would be most eastward and closest to larger parks. This can be seen in Figure 5. My second and third choices were also in areas with high vacancy rates and near larger parks. My fuzzy reasoning led me to these top three areas of consideration (Scott, 2022).

Analysis:

Issues like gentrification, rent increases, vacant properties, and limited affordable housing affect low-income individuals' access to affordable living arrangements. Housing insecurity is a multivariable issue that cannot be solved by one straightforward solution.

The often white, upper-class property owners oppose any new development that could affect their property value (McNee, 2021). In San Francisco new development of affordable housing faces opposition. One solution that bypasses the long, drawn-out political deliberation of new construction is to place affordable units in existing properties. Specifically, this could be done by transforming vacant properties into affordable housing.

Non-profit organizations and community land trusts supply loans for groups to buy properties to convert into affordable housing. The rent that would otherwise have gone through a private owner goes directly to pay off a loan. This prevents private owners from increasing rent unexpectedly or matching market trends. Renters only pay a portion of the monthly mortgage, utilities, and repairs. These loans allow housing to remain more affordable and bypass market-determined prices. Once the loan is paid off on the property, the monthly payments drop significantly (SFCLT, 2021).

Appendix A: Critical reflection on spatial analysis

A GIS spatial analysis approach is practical when identifying access to certain public utilities. In future projects, I will include racial inequities and redlining via the HOLC dataset (Lavery, 2021). Economics, city planning, and environmental justice are spatially related to historic zoning and development regulations that may have affected Black, Hispanic, Jewish, and Asian communities. This is important to look at when identifying access to affordable housing, but no matter the research subject, racist regulations negatively impact these demographics more disproportionately.

In future research, I would also like a more quantitative approach to determining the best suitable locations for affordable housing. Assigning weights to variables and determining certain thresholds of importance could lead to a more comprehensive project. Also, finding research on standardized affordable housing and urban planning guidelines would be helpful. One variable I would like to include in newer renditions of my research is how the size of a park impacts public health. I found ample access to parks in most affordable housing in San Francisco, but sometimes the parks were less than 0.01 sq miles.

Even with my first GIS project, I was able to supply stakeholders with helpful information. Being aware of vacancies in the top three locations I mentioned could eventually lead to acquiring a property for conversion into affordable housing.

Aside from the tools and applications I used in my project, GIS is very relevant in data analytics. The integration potential of Rstudio and SQL scripts makes ArcGIS a powerful platform. Data visualization is essential, so using maps as a visualizer is an advantage of ArcGIS. Misrepresenting data to portray bias is one limitation of GIS. Using more quantitative processes could combat this. Overall, I am excited by the work I was able to do and looking forward to using ArcGIS in future projects.

Appendix B: Table of GIS skills used

Skill	Category	Use
Download and displayed shapefiles from sources other than those provided to you in the lab.	Generating new data	Downloaded data from SF.gov and California Forest Observatory.
Join	Generating new data	Joined vacancy locations to census data
Query	Analysis	Narrowed focus on the City of San Francisco.
Create New Feature	Analysis	Made a shapefile of the coast of San Francisco. Used this to clean up the edges of my raster data.
Euclidian Distance	Analysis	Represented distance to parks.
Fuzzy Logic	Analysis	Final selection of most suitable census tracts for new affordable housing.
Several polygon layers effectively presented on the same map	Map presentation	Dot density (affordable housing locations) over a graduated color map (% tree coverage).
Multiple maps in one map	Map presentation	Showed a zoomed-in section of San Francisco to narrow focus on a high density of affordable housing locations.

Appendix C: Project folder organization

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Name	Date modified	Type	Size
Administrative	12/6/2022 11:34 PM	File folder	
CalEnviroScreen3	11/30/2022 8:59 PM	File folder	
Census	11/30/2022 6:35 PM	File folder	
Euc_Dist	12/6/2022 11:33 PM	File folder	
IMAGES_&_MAPS	10/24/2022 8:27 PM	File folder	
info	11/29/2022 1:37 PM	File folder	
Mayor's Office of Housing and Commun...	11/30/2022 8:59 PM	File folder	
Parks	12/6/2022 11:34 PM	File folder	
San_Francisco_Centroids	11/10/2022 1:46 PM	File folder	
Trees	12/6/2022 11:34 PM	File folder	
Vacancy	12/6/2022 11:34 PM	File folder	

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