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When Disparities Become Deadly: Spatial Differences in PM2.5 Levels Within the City of Pomona, California

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When Disparities Become Deadly: Spatial Differences in $PM_{2.5}$ Levels Within the City of Pomona, California

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Abstract

This thesis discusses the disparities in particulate matter concentrations between different neighborhoods in the city of Pomona, California, and explores the historical, political and social factors that have shaped these spatial patterns. I argue that urban growth patterns in Pomona, which are historically marked by race and class segregation as a consequence of past discriminatory housing practices, have led to the disproportionate concentrations of air pollutants in low-income, Latino communities in South Pomona.

South Pomona, surrounded by freeways and with a mixed residential-industrial landscape, carries the burden of multiple sources of pollution that impact the wellbeing of its communities. Due to the absence of a local air quality monitoring system, there is a lack of information about and understanding of how poor air quality may be in part responsible for the high prevalence of cardiovascular and respiratory illnesses among South Pomona residents. I carry out a pilot study in which I measure $PM_{2.5}$ level in different residential locations in Pomona to demonstrate the significant variation in air quality, even at a local level. I find that low-income, Latino communities are exposed to significantly higher levels of $PM_{2.5}$ than richer, non-Latino white communities, and that the I-10 freeway is a significant source of pollution that could account for the marked differences in $PM_{2.5}$ between North and South Pomona.

I conclude my thesis with regional and local recommendations to address the environmental justice issue of air pollution in Pomona. I discuss the need for community-based approaches to environmental justice alongside regional programs aimed at reducing emissions state-wide. Local air quality monitoring, in addition to improved enforcement of emission regulations in South Pomona, are essential in ensuring that South Pomona communities can breathe cleaner air. Community-based approaches should include collaboration between Pomona residents, grassroot organizations, larger non-profits, and federal agencies. Additionally, I argue

for more democratic planning practices that involve South Pomona residents through better language accessibility and the use of existing grassroots organizations like Clean and Green Pomona and United Voices of Pomona for Environmental Justice to build collaborations between the community and city government.

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Introduction

On January 27, 2021, a week after his inauguration, President Biden signed several executive orders aimed at tackling climate change, including one that would "Secure Environmental Justice and Spur Economic Opportunity" (Barnes et al., 2021). This was one of the first steps of the Biden-Harris administration to honor its strong commitment during the election campaign to address environmental justice in the United States. The order ensures that environmental justice becomes "a part of the mission of every agency by directing federal agencies to develop programs, policies, and activities to address the disproportionate health, environmental, economic, and climate impacts on disadvantaged communities," while charging two new White House Councils with the responsibility of ensuring "a whole-of-government approach to addressing current and historical environmental injustices" (The White House, 2021). In addition, a Climate and Environmental Screening tool will be developed to identify disadvantaged communities, which, under the Justice40 initiative, will receive "40 percent of the overall benefits of relevant federal investments" (The White House, 2021).

These administrative actions show a significant change of tone from the previous administration, which had undermined the environmental justice movement. Over its four years in office, the Trump administration had "officially reversed, revoked or otherwise rolled back" ninety-eight environmental regulations (Popovich et al., 2020). Additionally, it made several proposals for major budget cuts to key EPA programs, with many of these programs having "explicit significance to Environmental Justice" (Outka, 2019). Congress had fortunately rejected these budget cuts, which allowed environmental justice work to continue. Nevertheless, under the Trump administration, enforcement of regulations has declined, with the New York Times finding that the EPA initiated one-third fewer civil cases against polluters than under the Obama administration (Lipton and Ivory, 2017). The attitude of the Trump administration towards environmental justice communities was clear: their issues were insignificant and their communities were disposable. However, with the arrival of a new administration that believes in climate science and recognizes the disproportionate impacts of climate change on communities of color (Climate News, 2020), there is hope that the fight for environmental justice is brought to the forefront of the political agenda.

But the Biden-Harris administration is faced with a significant challenge that has only been exacerbated by the neglect of the Trump administration: the COVID-19 pandemic. Since the end of January 2020, when the virus was believed to have spread to the United States, until the mid-April 2021, an estimated 562,000 Americans died from COVID-19; during that same timeframe, 31,200,000 Americans were infected (CDC, 2021). However, the burden is not shared equally, with numerous studies indicating that low-income communities of color are disproportionately affected by the novel coronavirus. In fact, African Americans are 1.9 times, Latinos 2.3 times, and American Indians 2.4 times as likely to die from the virus as white Americans (CDC, 2021).

While there are many contributing factors, higher levels of exposure to air pollutants can account for part of this disparity. Several studies have found a link between existing social and environmental burdens in low-income communities of color and the disproportionately high impact COVID-19 had on these neighborhoods. Research has demonstrated an "excess burden of infection and death" (Adhikari et al. 2020) in poorer urban communities, but race and ethnicity are even stronger indicators of how a community is impacted by the virus. Additionally, a positive correlation has been found between COVID-19 related deaths and areas with higher levels of air pollution (Petroni et al. 2020), with an estimated 17% of COVID-19 deaths in the

United States being associated with exposure to higher levels of particulate matter (Pozzer et al., 2020). In the United States, communities of color are exposed to more sources of pollution than their white counterparts, with Latinos having the highest exposure rates for 10 out of the 14 particulate matter (PM) components and African Americans having higher levels of exposure than whites for 13 out of the 14 $PM_{2.5}$ components (Bell and Ebisu, 2012).

The threat of the COVID-19 pandemic, and inevitably future pandemics, is inextricably linked to environmental justice issues, and the fight to protect people from this threat must therefore put environmental justice at the forefront. According to the Environmental Protection Agency (EPA), environmental justice can be defined as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (EPA, 2021). Within this definition, it is understood that environmental burdens are equally distributed across communities, and that all groups should have a voice in decision making that impact their environment and wellbeing. Environmental injustice, therefore, refers to the disproportionate burdens that certain groups carry, with unequal access to a healthy environment.

Spatial justice, which can be understood within the framework of environmental justice, addresses "the fair and equitable distribution of space of socially valued resources and opportunities to use them" (Soja, 2010). Clean air, in this case, is a socially valued resource that provides a healthy environment for people living in spaces of better air quality. Spatial injustice, according to Peter Marcuse, professor of urban planning at Columbia university, "is derivative of broader social injustice" and "cannot be isolated from the historical and social and political economic context in which they exist" (Marcuse, 2009). Sacrifice zones, spaces in which communities live “immediately adjacent to heavy polluted industries” (Bullard, 2011), are the spatial product of social injustice. In “Racism is Killing the Planet,” Hop Hopkins argues that “you can’t have sacrifice zones without disposable people, and you can’t have disposable people without racism” (Hopkins, 2020). Hopkins refers to the many low-income communities of color that are being exposed to multiple environmental burdens due to historical and contemporary racist discourses that justify making profit at the expense of the well-being of these communities.

City of Pomona

The city of Pomona, located on the eastern border of Los Angeles County, with five freeways running through its city limits, is an example of how historical, social and political factors create spaces of injustice with disproportionate environmental burdens. Large tracts of industrial land use, particularly in its southeastern neighborhoods, in addition to the heavy diesel traffic that rolls in and out of the city, exposes Pomona’s 152,000 residents (Data USA, 2021) to air pollution with significant adverse health effects.

Figure 1. Map showing the location of the city of Pomona within Los Angeles County. (Layer Source: Los Angeles GeoHub, 2015)

Compounding this health-compromising situation are the discriminatory housing practices and undemocratic urban planning in the past have led low-income communities of color living in closer proximity to sources of pollution than their richer, whiter, counterparts. Detecting this aspect of Pomona's environmental burden has been lacking, due to an absence of local air monitors in the city. Without the ability to measure Pomona's air quality, it is difficult to assess the spatial differences in air pollution concentration between its neighborhoods; there is a demonstrable need to explore the disparity in exposure within the city of Pomona to understand to what extent disadvantaged communities are impacted by this environmental burden. This thesis does just that, offering a snapshot of some of the consequences that air pollution has brought to the bodies of some of Pomona's more vulnerable citizens.

The California Communities Environmental Health Screening Tool (CalEnviroScreen 3.0, 2018), which measures the prevalence of environmental burdens in California communities and their vulnerabilities to it, identified the majority of the Pomona city census tracts to be in the top 10 percentile (91-100%) of "California communities by census tract that are disproportionately burdened by, and vulnerable to, multiple sources of pollution." (CalEnviroScreen, 2018). More specifically, most Pomona census tracts are identified as being within 93rd percentile of highest particulate matter burden. This means only 7% of California census tracts have a higher particulate matter burden than Pomona.

High concentrations of particulate matter (PM) - particle pollution smaller than 10 micrometers in diameter - has been identified as one of the greatest global risk factors for early death as exposure to particulate matter, even at low concentrations, can cause serious adverse health effects in humans (Watts et al. 2019). Several grassroot organizations, including United Voices of Pomona for Environmental Justice, and Clean and Green Pomona, have recognized air pollution as a significant environmental justice issue in the city and are actively pushing for improved regulations and air quality solutions in the interest of Pomona residents (Clean & Green Pomona, 2020; United Voices of Pomona for Environmental Justice).

In this thesis, I explore the spatial differences of $PM_{2.5}$ within the city of Pomona to understand the disparities in exposure to air pollution within the city. I argue that a combination of historical, social and political factors can account for the disparities in the concentrations of particulate matter that different neighborhoods are exposed to. In addition, the use of regional level air quality measurements, along with a lack of local air monitors, are undermining the impacts of air pollution on the health of the residents of the city, especially in low-income communities of color. In the first section, I outline the historical context of the city, discuss how spatial injustice was entrenched in the city since its founding, and how undemocratic planning practices have allowed sources pollution to develop in proximity to marginalized neighborhoods. In the second section, I address the potential health impacts that exposure to particulate matter may have on residents, and how it may account for the disproportionately high levels of cardiovascular and respiratory issues, in addition to the significant number of COVID cases and deaths in the city. In the third section, I outline the current methods used by the EPA to monitor pollutant concentrations, and how the low spatial resolution of the measurements does not sufficiently account for neighborhood differences in $PM_{2.5}$ concentrations, and may therefore be underestimating $PM_{2.5}$ concentrations in neighborhoods burdened by multiple sources of air pollution. Lastly, I discuss recommendations for at a state and local level to address the problem of air pollution and environmental injustice in the city of Pomona.

History of Pomona, California

The history of air pollution in Pomona dates back to the late 1800s. It began with the thriving citrus industry, which gave Pomona its name; and includes the wartime industrialization during the 1940s and 1950s, the introduction of freeways at the same time, and to the recycling, waste and pallet facilities that currently dominate the city's industrial landscape. These significant changes in the urban environment are just a small part of Pomona's elaborate history that define the current environmental issues directly impacting its residents, with a disproportionate burden on the low-income Latino neighborhoods. In this section, I explore these historical influences in the hope of gaining a deeper understanding of the complexity of the spatial injustices that exist within the city.

Around the turn of the twentieth century, Pomona was an essential part of the California citrus industry, so much so that it was labelled the "Queen of the Citrus Belt" (Davis, 1994). The artesian wells in the area allowed for intensive irrigation of citrus trees (Neiuber, 2014), and the Santa Fe Railroad, built in 1887, helped distribute the crops' across the United States (Pomona College, 2016). The railroad also made travel easier, and there was an influx of people hopeful to find their place in the profitable citrus industry. By the 1930s, citrus was the state's main agricultural product, and the California citrus industry accounted for "sixty percent of the nation's crop and twenty percent of the world's supply" (Gonzales, 1991). However, the thriving industry did not come without its issues, as it introduced a new form of environmental degradation into the landscape.

Housing Segregation

Whilst rich white landowners benefitted the most from the industry, the majority of the workers toiling away in the orchards were Mexican, and some Indigenous (Gordon and Wixon).

Large ranch owners provided housing for their employees, but workers were strictly segregated based on their social and ethnic status (Gonzales, 1991). In this way, Mexican pickers lived in separate housing from Anglo-Americans and in segregated parts of the city. In Pomona, Mexican picker camps were located south of the South Pacific Railroad tracks and the houses were smaller and of inferior quality (Nelson et. al, 2016). The railroad acted as a clear physical line separating the Mexican community from the Anglo-American community, a form of spatial segregation that remained intact for many years to come.

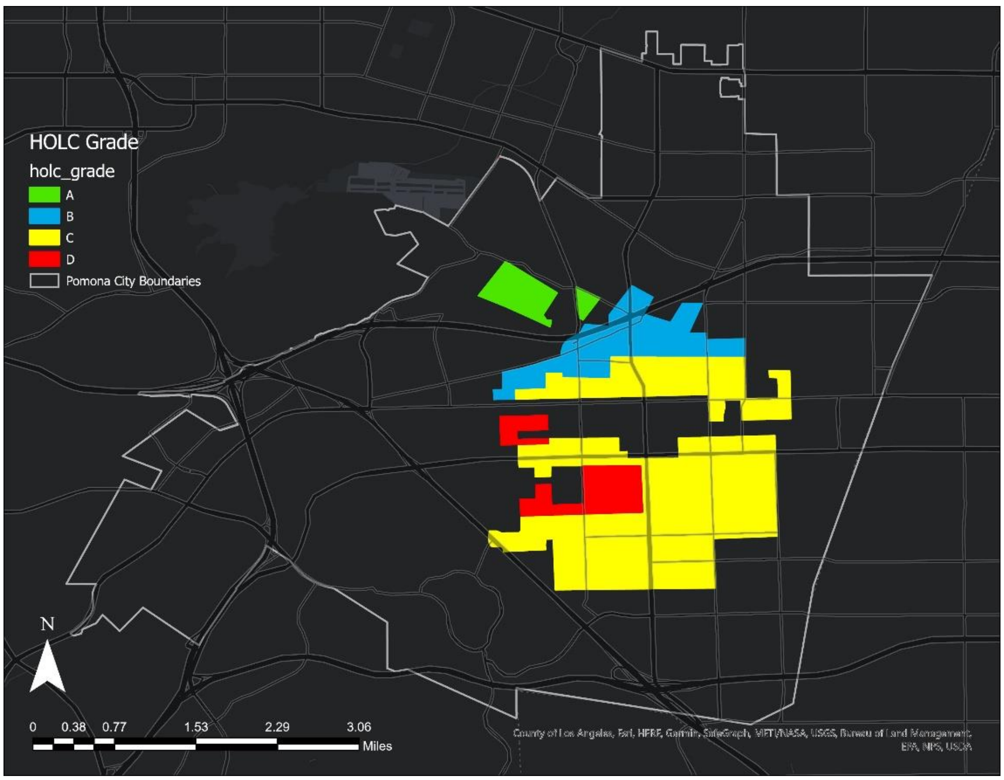

Figure 2: Home Owners' Loan Corporation Redlining Map of Pomona.(Layer Source: Nelson et al., 2016)

In the 1930s, the Home Owners' Loan Corporation (HOLC), an agency of the federal government, produced red-lining maps that only further entrenched the spatial segregation that citrus helped establish in Pomona. The federal government and the private sector regularly used the maps in making investment and mortgage decisions, which promoted racist housing practices and exacerbated the existing segregation and disinvestment in communities of color. The HOLC map of Pomona is visible in figure 2.

Note the sharp contrast between the appraisal given to neighborhoods in the north of Pomona, which were predominantly given ‘A’ or ‘B’ grades, and the south of the city, with ‘C’ or ‘D’ grades. The areas on the south side were referred to on the maps as being on “the wrong side of the tracks" (Nelson et al. 2016). The areas that were historically the Mexican picker camps were turning into thriving Mexican communities with jobs in nearby industries, but HOLC redlining maps described this “infiltration of Mexicans" as the reason as to why the “area is hopelessly gone and cannot go much further” (Nelson et al. 2016). These neighborhoods were also poorly graded for the inaccessibility to public facilities and a general lack of infrastructure, which was a result of the existing racial segregation and disinvestment in these neighborhoods since days of the citrus industry, with the maps perpetuating these disparities.

Smudge Pots and Air Pollution

Working in the groves and orchards was rough, and workers had to deal with the immense smog released by the orchard smudge pots. Farmers would burn diesel oil in these smudge pots to maintain a warmer temperature in the orchards and prevent the frost from affecting the fruit trees (Blackstock, 2015). However, apart from heat they released, they also emitted significant amounts of smoke, carbon dioxide, particulate matter and water vapor. Fighting Frost with Fire, an article published in a 1912 issue of Country Life in America, described the battle between farmer and frost:

As one from the automobile looked over the valley, filled with flame and smoke, hell itself appeared to be blazing through tens of thousands of breaks and perforations in the earth; a quarter of a million smudge pots smoked and flamed." (Mills, 1912)

Figure 3 (Top) View of Mt. Baldy, smudge pots line the road to the left. Source: (Loyd) (Bottom) Smudge Pots on Farmland in Southern California. Source: (Grogan, B., 1991)

Early reports mention that those working on the orchard came home “with their faces blackened and coughing up black phlegm” (Waldie, 2017), and although the health effects of this smog is poorly documented, the problem became so significant that in 1917 the city of Pomona formed a “’smokeless’ smudge committee” and “offered $50 for the invention of a practical and cheap heat pot” to replace the smudge pots (Los Angeles Herald, 1917). During the late 1910s and throughout the 1920s, there were continuous pleas by residents to outlaw the use of traditional smudge pots, but it was considered essential to preserving high crop production in the highly profitable citrus industry. With Mexican and Indigenous workers in the field being most directly and immediately exposed to the toxins released by the smudge pots, this was the first of many instances in which people of color in Pomona carried a disproportionate environmental burden.

It was not until 1947 that the Los Angeles Air Pollution Control District called for the termination of four million traditional smudge pots (SCAQMD), along with limiting effluents from other point-sources such as “backyard trash-burning, rubbish collection, diesel truck exhaust” (Jacobs, 2015). Slowly but surely, the traditional smudge pots that produced the most smoke were phased out, and by the 1950s many farmers replaced them with cleaner technologies such as wind machines to maintain a consistent temperature in their orchards (SCAQMD).

World War II Industrial Boom

The gradual phasing out of smudge pots came around the same time as Los Angeles started dealing with far bigger sources of air pollution problems: car tailpipes and smokestacks. World War II brought major transformation to Los Angeles and its surrounding cities. Industrialization changed the "quiet, "small town" prewar character" of Los Angeles before the War into an "industrial giant" seemingly overnight (Verge, 1994). The wartime industry was considered essential in the United States military, and Los Angeles - no longer seen as distant from the nation's capital - became a target for federal investment in wartime goods. During the wartime, there was a lot of pressure on citrus industries to provide food, and so business was booming (Tobey, 1995). At the same time, there was a rapid expansion in the aircraft and shipbuilding industries to meet the needs of the military.

However, the end of the wartime boom meant the end of the citrus industry in Southern California. GIs returning home from the war and defense workers moved to Los Angeles with their families in search for better job opportunities, creating a rapid population increase, which in turn significantly increased the demand for industrial space and housing developments (Hayden-Smith, 2019). With increased land prices and taxation, along with real estate developers who offered high prices to farmers for their land, citrus producers were encouraged to sell their land to make way for new housing developments, schools and other urban facilities. Additionally, Southern California was losing its position as the only major producer of United States citrus, as Florida had become a major competitor. In the 1920s, California boasted 75% of the total citrus orchards in the United States, but by the end of the 1940s this percentage had dropped to 29%, while Florida's citrus industries grew from 25% in the 1920s to 55% by the end of the 1940s (Griffin and Chatham, 1958). Pomona, now a target of major development from industrialization and suburbanization, saw its citrus orchards rapidly disappear in place for a more industrial landscape (King, 2001), bringing with it roads to cater to a population that increasingly depended on the car.

Automobiles and the Freeway

The story of the automobile in Pomona starts long before the arrival of the freeway. In 1904, the Automobile Club of Southern California organized the first race from Los Angeles to Pomona. As this was a popular event, especially among the rich men who could afford cars, Pomona soon became a well-known location for races and rallies (National Park Service, 1986). In 1917, the club opened up an office in Pomona and by 1922 it had its own building on Second Street. The group was an important presence in Pomona Valley as it pushed for legislation, for example the first gas tax, to finance the highways which were being planned throughout the 1930s and 1940s (National Park Service, 1986).

The boom of the automobile industry and the highway system was bittersweet for Pomona residents. The city was the “undisputed agricultural, commercial, and cultural center of the entire valley,” (National Park Service, 1986) and it was located far away from any other large towns. Downtown Pomona was an important commercial hub for surrounding communities up until the mid-1950s as it had a popular department stores like Bowen’s, an Orange Belt Emporium and other markets that surrounding towns did not have. A survey carried out in Downtown Pomona in 1944 found that there were 46,000 people entering the area within a 16-hour period, with 83.2 percent of these people arriving in automobiles (The Pomona Progress Bulletin, 1944). In addition, Pomona hosted the yearly Los Angeles County Fair on its Fairplex grounds, with 80% of the visitors coming from the city of Los Angeles, and therefore congestion between the two cities was severe during the fair season (The Pomona Progress-Bulletin, 1948). There was a general consensus within the city and surrounding areas that Pomona needed improved automobile access to support the thriving downtown area.

To meet this perceived need, the state drew up plans in the mid-1940s for the Ramona freeway between Los Angeles and Pomona with the purpose of reducing the travel time between the two cities from 57 minutes to 36 minutes (The Pomona Progress Bulletin, 1944). While there was little-to-no dissent from the Pomona community about whether the freeway should come to Pomona, there were conflicts regarding the route it would take through the city. The state highway engineers recommended a route south of Ganesha park - the largest park in the city - and the fairgrounds, but many residents of Pomona wanted the freeway to run north of the fairgrounds, mainly due to concerns about property damage. A Citizens Committee was formed to challenge the state-picked route, and it was signed by 5000 residents, more than a fifth of the 24,000 people population (Los Angeles Almanac). In a 1948 newspaper article from the *Pomona Progress Bulletin*, the committee claimed that the original routings would "cut these cities in two," - referring to El Monte and Pomona - "with great loss in property values and hazards and inconveniences to every citizen" (The Pomona Progress Bulletin, 1948).

The story of the freeway in Pomona differs from the story of the freeway in many parts of Los Angeles County. While, in places like East Los Angeles, thousands of homes were destroyed by freeway construction in racially diverse neighborhoods in the name of "slum clearance" (Fleischer, 2020), the Romona freeway route went through predominantly the upper- and middle-class white neighborhoods on the city's north rather than the lower-income, neighborhoods of color further south in Pomona. These richer, whiter communities proved to be a strong opposing force against the state's plans for the freeway construction. Their privilege allowed their concerns to be heard, an opportunity that East Los Angelinos could not command. In fact, the committee was able to pass an ordinance that granted "power to the City Council to negotiate with the State Highway Division” (The Pomona Progress Bulletin, 1949), which forced the state into communication with the City Council.

While many of these large property owners initially stood with the Citizens Council against the routing south of the fairgrounds, they eventually accepted the state’s decision in the name of progress. For example, a newspaper article mentioned that "Elias C. Crisp, 340 Preciado street, businessman and newly elected president of Pomona Junior Chamber of Commerce, pointed out his home property is along the state routing of the freeway... He considered the city's interests as a whole more important than his own desires" and "Allen P. Nichols, prominent pioneer Pomonan, in a statement today on the routing of Ramona freeway through Pomona summed up his views as follows: ‘I wanted it north of the county fairgrounds, but we need a freeway and if we cannot get what I would like, I am ready to accept what we can get.’” (The Pomona Progress Bulletin, 1950). Business owners and leaders were in favor of the freeway because they believed it would bring economic prosperity to the city, which they would greatly benefit from. Although many of their properties stood in the way of the state’s route, they could afford to move - a freedom that many south Pomona residents did not share.

The opening of the Ramona freeway – now referred to as the San Bernardino Freeway - in 1954 attracted housing developments in the area, especially north of where the I-10 stands now. Many white, middle-class families decided to move into Pomona as it “seemed an easy drive from central Los Angeles” (City of Pomona, 2014), and just far enough from the decay of the city center. With the growing population came industrialization, especially around the Union railroad tracks, and some in older residential blocks (City of Pomona, 2014). The rise of the private automobile also allowed for expansion of commercial lots outside of downtown in areas like Holt Avenue and Indian Hill (City of Pomona, 2014).

The post-wartime industrialization in Pomona is perhaps best marked by the 1953 arrival of General Dynamics, an aerospace and defense company. That year, the majority of the stock of Convair, an aircraft company located in Pomona, was bought by General Dynamics and it was turned into a General Dynamics branch (The Pomona Progress-Bulletin, 1953). The Pomona branch was "to be entirely devoted to the manufacture of guided missiles" and was best known for producing the Terrier missile, which was "the first sea-going anti-aircraft guided missile in world history" (Kelley, 1965). Numerous General Dynamics engineers were assigned to Pomona, and houses for the engineers and their families were predominantly built in the north eastern parts of the city between Towne and Garey avenue; many of these were constructed between the mid-1950s and 1960s. General Dynamics, whose plant was located in the most eastern part of the city just north of Mission Boulevard (Rodriguez, 2017), immediately became one of the biggest employers in the city; by 1965, it employed 6,200 people (The Pomona Progress-Bulletin, 1962). The large impact of the arrival of General Dynamics and other industries is evident by the population of Pomona almost doubling from 35,405 in 1950 to 67,154 in 1960 (Los Angeles Almanac).

Whilst there is not much reported on local sources of air pollution in Pomona in the 1950s, we must consider the inevitable effects that suburbanization and industrialization had on the city. A rapidly rising population also meant a sharp increase in the number of cars, which quickly deteriorated the air quality in Pomona. The situation was so dire that the Air Pollution Control District used to predict eye irritation as a consequence of bad air quality when they reported on weather conditions in newspapers (The Pomona Progress Bulletin, 1953).

In the early 1950s, California researchers first made the link between the declining air quality in Los Angeles County and car emissions (EPA,2020). Haagen-Smit, a Dutch chemist, found that ozone was the culprit for the "decrease in visibility, crop damage, eye irritation, objectionable odor, and rubber deterioration" that the Los Angeles smog caused (Haagen-Smit, 1952). He found that ozone was a secondary pollutant created in the atmosphere through a photochemical reaction of sunlight with "hydrocarbons from oil refineries and the partially unburned exhaust of automobiles with nitrogen oxides" (SCAQMD). Of course, these findings were concerning Los Angeles county citizens: if these were only the short-term, visible effects of smog, what were the long term, less visible effects? *Effects of smog on health puzzle*, an article published in the Pomona Progress Bulletin in 1955 discusses the reflections of a local engineer on the relationship between air pollution and human health. The article mentions that "he did not subscribe to the viewpoint that unless adverse health effects can be demonstrated, air pollution is not a matter of public health concern" (The Pomona Progress Bulletin, 1955), suggesting he believed that air pollution is linked to poor health outcomes, there simply was not enough technology to demonstrate it. This illustrates the overall issue that public health scientists were facing: they suspected that air pollution had detrimental impacts on health but methods were not yet devised to truly establish a relationship.

Haagen-Smit and his fellow public health scientists encountered another major obstacle – the automobile and oil industries. As Chip Jacobs and William Kelly discuss in *Smogtown,* these industries "eyed the region's ever-bulging population as the most fertile car market the world had ever seen" (Jacobs and Kelly, 2008), and if the results of his study gained public attention, it could pose as a major threat to the tremendous profit these businesses were making. When this started happening, "industry-sponsored research accelerated" (Jacobs and Kelly, 2008), driven by the Stanford Research Institute. They questioned the validity of Haagen-Smit's experiments, claiming they were unable to replicate his findings and arguing that the air that the oil produced was “no more irritating than fresh outside air” (Jacobs and Kelly, 2008). Haagen-Smit, while aware of the immense power the oil lobby held and their ability to make his life difficult, was extremely confident in his study and went on to prove his findings once more. He was able to shut down SRI’s claims by arguing they had missed out on important lab procedures, which is why they could not replicate his results. He even went as far as building a “phone booth-sized ‘smog chamber’” that directly demonstrated the impacts of smog on plants, which were brought in green and were left as “lifeless stalks within days” (Jacobs and Kelly, 2008). It was no longer a question of doubt: smog produced by postwar industrial activities were everything but harmless.

In 1959, the California Motor Vehicle Pollution Control Board was formed in the hope of pushing for cleaner automobile technologies to fight the smog problem, and by 1963 all new cars were required to carry a device that would re-burn some of the car fumes rather than emit them into the atmosphere. However, rumors spread that the device had a negative impact on the engine, and the retrofit program was quickly rescinded. That being said, congress kept pushing for regulations that would improve air quality, and in 1963, the Clean Air Act (CAA) was passed. This legislation established a federal program that would authorize and encourage research and development into technology that could monitor and reduce air pollution (EPA, 2017). Throughout the 1960s, new technologies for cleaner cars were constantly being tested, an effort that would be paid-off a couple years later with the invention of the catalytic converter (SCAQMD).

During this same period, environmental activism was accelerating at a rapid pace, and through scientific research, environmental protests, and the publication of books like *Silent Spring* by Rachel Carson, which exposed the harms of toxins on humans and animals (Carson, 2015), there was an increased awareness of environmental issues by the general public. By the 1970s, air quality concerns had become a frequent topic of conversation and discussion, which is reflected in the increase of air quality related articles in local newspapers at the time.

In the Action Line section of the *Pomona Progress Bulletin,* which allowed residents to express complaints, an article was published in 1972 titled *What's Being Done About Reducing Air Pollution?* The author, a Pomona local, describes the "extreme air pollution that begins about the Fontana industrial area, and continues at the will of the prevailing winds to cover the entire valley," along with the contribution of car emissions to the smog (Progress Bulletin, 1972). The author was referring to the Kaiser steel company, built in Fontana in 1942 to meet the needs of the shipbuilding and wartime industry. It came under fire by environmentalists and concerned locals as being "the primary source of local air pollution" (Cushing, 2013) in and around the city, reaching as far as 18 miles away in the city of Pomona. Although the claims of the plant's impacts on local air pollution proved to be a severe overestimation after a plant shut down led to little to no improvements in the smog conditions (Conford, 1995), it demonstrates the increased pressure placed on industries - which had up till now enjoyed a lot of freedom in their industrial activities – to regulate their emissions.

Due to the rising concerns regarding air quality and environmental issues in general, in 1970, Congress decided to establish the Environmental Protection Agency (EPA) - an agency which would take charge of many of the environmental responsibilities of the government, allowing this agency "permit response to environmental problems in a manner beyond the previous capability of government pollution control programs" (EPA, 2021). In addition, Congress took a different, stronger stance on the matter of air quality by placing the needs of the public above business interests, and setting "performance standards beyond their usual technological capabilities” (Lee et al. 2010) - a strategy otherwise known as technology-forcing. In 1970, Congress passed the amendment that called for 90% reduction in car emissions by 1975, and EPA was charged with the responsibility of enforcing it. There was major resistance from the automobile industry, and they argued that the standards were “unobtainable, disastrously expensive and environmentally unnecessary” (Weisskopf, 1990). Throughout the 1970s, automobile motor vehicle emissions remained the most significant contributor to air pollution, and the new standards were pushed back several times with the excessive lobbying of the automobile industry. The catalytic converter, invented by Dick Klimisch of General Motor Corps, was a technology that turned many of the gases that are by-products of car combustion and are detrimental for air quality, into harmless gases (Weisskopf, 1990). Ultimately, the catalytic converter was the “only feasible technology capable of reducing all three major pollutants” (Lee et al. 2010) that the EPA standards aimed to reduce. Whilst the technology-forcing was eventually successful in its goal of substantially reducing car emissions, it was not until the late 1970s that all new cars were fitted with a catalytic converter.

In Pomona, four more freeways had been in construction since the completion of the San Bernardino freeway. The Pomona Freeway (SR60), running from Los Angeles to Moreno Valley, was completed in 1964. SR 57, the Orange freeway running west of the city, was constructed throughout the 1950s and completed in the 1970s (CA Highways, 2020). The Corona Freeway (SR71) section, a four-lane expressway running from North Pomona to Corona which was completed in 1998, and finally the I-210, the Foothill Freeway running north of the city, was constructed in stages mainly throughout the 1960s, 1970s and 1980s, was completed in 2007 (Interstate Guide, 2020). Whilst the arrival of the San Bernardino freeway had initially brought economic prosperity to the city throughout the 1950s, the freeways were, ironically, also the reason for the city's gradual economic downfall in the late 1960s and early 1970s. The once booming-and-bustling downtown of Pomona now seemed out-of-date with its old store fronts, and newer malls and developments near the freeways were pulling visitors away from the city into neighboring cities. Montclair mall - now known as Montclair Plaza - which had been opened in 1968 (Nisperos, 2017), by 1972 "was attracting 36% of Pomona shoppers" (City of Pomona, 2014). Although Pomona was no longer experiencing the economic benefits of the freeway, it had to deal with the consequences of increased traffic congestion and declining air pollution.

Demographic Changes

The economic downturn in Pomona was not the only change the city was experiencing; throughout the 1970s, the demographics shifted significantly. After the Watts Riots in 1965, a lot of Black residents moved away from central-city neighborhoods in Los Angeles to cities on the outskirts of Los Angeles county - including Pomona - or to neighboring counties to escape the violence and the increased congestion in the inner-city (Texeira, 2001). Between 1970 and 1978, the Black population increased by 5,400 in Pomona. During the same period, 14,000 white residents in Pomona, who had witnessed the downtown area turn into a ghost town and saw the quality of Pomona education rapidly deteriorating (Pomona Progress Bulletin, 1973), left the city. Within those seven years, the minority population, which mainly included the recently arrived Black residents and the growing Mexican American community, had increased from 30% to 44% of the total population (The Los Angeles Times, 1978).

In Pomona, as communities of color migrated into the city and white residents left, remaining white citizens blamed the newcomers for the deteriorating image of the city. In *Ecology of Fear: Los Angeles and the Imagination of Disaster*, Mike Davis describes the transition of Pomona from a model middle class suburb to a city that "displays most of the pathologies typically associated with a battered inner-city" (Davis, 1998). The way he describes the overall sentiments that white people in older suburbs had towards people of color also encompasses what was happening in Pomona:

> In the meantime, the stranded and forgotten white populations of these transitional communities are too easily tempted to confuse structural decay with the sudden presence of neighbors of color. The vampirish role of edge cities in sucking resources from older or poorer suburbs is less evident than the desperate needs of growing populations dependent on the dole. Political discourse, moreover, constantly valorizes resentments against the poor and people of color, while remaining discreetly silent about the real structures of urban inequality (405).

The resentment towards communities of color in Pomona was evident in a newspaper article in 1978: "For at least a decade, significant housing and commercial development have passed this city by. During the same period, Pomona's white population dwindled, the minority population grew, living conditions deteriorated and the city's image suffered" (The Los Angeles Times, 1978). The article directly reflects how residents ascribed the city's declining reputation to the incoming minorities, when in fact the city's decline could be attributed to the loss of economic engines such as General Dynamics and to new commercial and residential developments that were appearing in younger suburbs like Montclair and Diamond Bar.

Since the early 1960s, civil rights groups had exposed discriminatory housing policies in Pomona. In 1963, the National Association for the Advancement of Colored People (NAACP) filed lawsuits against real estate brokers who were involved in racist housing practices, which was described as being a "widespread" (The San Bernardino County Sun, 1963) issue in the city. The NAACP exposed many instances of residents of color being denied housing in certain areas of Pomona (The San Bernardino County Sun, 1963), but these discriminatory practices continued throughout the 70s and far into the 1980s. The in-and-out migration patterns of the 1970s in cities like Pomona "fueled residential segregation, mirroring housing trends in central cities" like

Los Angeles (Texeira, 2001). In 1987, NAACP carried out a study of "the decay of some Pomona Neighborhoods" (Estela, 1987), in which it found that there were "enclaves throughout the city where people are shut out from the community as a whole", especially near the downtown area (Estela, 1987). They also found that First Interstate, a bank that had two branches in Pomona, had "made no home mortgage loans in three primarily Black and Latino census tracts in Pomona" (Estela, 1987).

While residents of color were struggling to make payments and others were losing their homes to foreclosures, developers had started constructing new housing subdivisions in other parts of the city in the hope of attracting more affluent residents into the area. In the western part of the city, Louis Lesser Enterprises, Inc. had started developing on one of the largest open parcels known as Phillips Ranch (The Los Angeles Times, 1964). The housing prices of the tax-subsidized development ranged from $60,000 to $200,000 - which at that time was in the upper-middle income range. One of the city planners involved with the development hoped it would "bring in some [buyers] from Orange County to balance out our population" – a balancing that presumably referred to a richer, whiter homebuyers than the average Pomona citizen at the time (The Los Angeles Times, 1978). The houses sold rapidly, but the Phillips Ranch community was developed in such a way that intentionally distanced it from the city of Pomona as much as possible. An article in the Los Angeles Times mentioned that "many of the original builders in Phillips Ranch made little reference to the fact that the development was in Pomona, identifying their model offices as being in 'Phillips Ranch, Calif,'" (Lustro, 1989). There was conflict between the city and the developers as to which school Phillips Ranch students would attend, with developers showing a strong preference for Diamond Bar schools over Pomona schools (Pomona Progress Bulletin, 1977). Phillips Ranch, subsidized by the taxes paid by Pomona residents, was trying hard to isolate its residents from the rest of the city while still benefiting from city services.

By the late 1980s, 51% of Pomona's population was Latino, 28% non-Latino white, and 14% Black. Despite Latinos representing the majority of the population, they were severely underrepresented in the city council. Since the city had been founded in 1888, only two people of color had ever been elected to the council (The Los Angeles Times, 1985). In 1985, leaders and activists of the Black and Latino communities challenged the city's at-large voting system, in which "all of the voters can vote for a candidate in each of the four city council districts". This, they argued, was "a form of racism hidden but firmly entrenched in city politics" (The Los Angeles Times, 1985). Activists in the community went so far as to describe Pomona as "an apartheid city," with the at-large voting system fueling segregation and keeping the power in the hands of a few richer, white council members. They demanded a district system, in which the city would be divided into several districts where voters could only vote for their own district representative. This would give neighborhoods of color a better chance at electing candidates that accurately represent their communities. Council members, all white at the time, were against the idea, arguing that "those behind the suit are guilty of reverse discrimination." G. Stanton Selby, the city's mayor in 1985, called the suit against the at-large system "racist" (The Los Angeles Times, 1985). It was not until 1990 that the district system was put into place (Ward, 1990). Even then, a study carried out in 2003 found that Latino votes were still being diminished within the city elections, with district boundaries not having redrawn in over a decade. While the Latino population had grown to 64% of the total population, district boundaries did not accurately reflect population changes which diminished Latino voting power (Blish, 2003).

Acknowledging these demographic changes and discriminatory housing practices, and the resulting political underrepresentation of communities of color in Pomona, is essential to understanding how environmental injustice persists in the city. The housing and spatial segregation of richer, whiter communities from lower-income, communities of color since the founding of the city, has left Latino and Black communities with less access to city resources and political power and more exposed to pollutants than their white counterparts. Whilst there is not much historical documentation of how industrial development occurred in the city, what is evident is that the majority of it occurred in Southern parts of the city - where the industrial corridors can be found today. What my archival research on air pollution, development and demographic changes in the city demonstrates is that these industrial land uses are placed in areas that house communities that have historically been socially and politically marginalized since the days of the citrus industries, which has created a spatial injustice that persist to this day. Next, I will be discussing how air pollution impacts human health and how disproportionately high prevalence of adverse health impacts within the city could be associated with high levels of particulate matter.

Adverse Health Impacts and Air Pollution

According to the 2019 Lancet Countdown report, which represents the findings of 35 major agencies and academic institutions, exposure to $PM_{2.5}$ was found to be the greatest global risk factor for early death (Watts et al. 2019). Particulate matter is a general term for “a mixture of solid particles and liquid droplets found in the air” (EPA), and can include “acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles”. $PM_{2.5}$ are particles that are 2.5 micrometers in diameter or smaller, meaning that when they are inhaled, they are small enough to reach into the lungs and even the bloodstream. This can cause a variation of adverse health effects, including “asthma, chronic obstructive pulmonary disease (COPD), pulmonary fibrosis, cancer, type-2 diabetes, neurodegenerative diseases and even obesity” (Chen et al. 2016). Sensitive groups to these pollutants include children, elderly, people who are active outdoors and those already suffering from pre-existing respiratory and cardiovascular conditions (EPA). Many adverse public health outcomes are related to long term exposure to air pollution - and once developed - further exacerbate the effects of air pollution on the human body. Therefore, air pollution and negative health outcomes act as a violent cycle, making a population increasingly more vulnerable to pollution over time (Makri et al, 2007).

Asthma

Asthma is one of the most racially disparate health conditions in the United States and has a well-established adverse health impact associated with air pollution (Oraka et al. 2013). Communities of color experience disproportionately higher asthma cases and asthma-related emergency visits than white communities (Oraka et al. 2013), and also have a 1.28 times higher air pollution burden (Mikati, 2018). There is evidence to suggest that air pollution can exacerbate pre-existing asthma in individuals but also that it is directly related to new-onset asthma (Jerrett et al, 2008). Research carried out in 194 countries found that 13% of childhood asthma cases can be attributed to air pollution (Achakulwisut et al., 2019). At a biological level, high exposure to air pollutants in individuals with asthma was found to impair regulatory t-cells which are responsible for the suppression of the immune response, worsening the symptoms of asthma (Nadeau, 2010). Therefore, asthma sufferers living in areas of poorer air quality experience more symptoms compared to those living in areas of cleaner air (Lewis, 2013).

Asthma is a serious issue in Pomona, with 13% of the general population and 8% of children under the age of 18 having been diagnosed with the condition (Los Angeles County

Department of Public Health, 2018). An estimated 75 people per 10,000 of Pomona residents visit the emergency room every year due to asthma related issues (CalEnviroScreen 3.0). The asthma rate is higher in Pomona than about 80% of the California census tracts, suggesting there may be a number of local factors – such as air pollution – that are causing this disparity.

Cardiovascular illnesses

Over the past few decades, substantial research has also found a causal relationship between $PM_{2.5}$ exposure and cardiovascular morbidity and mortality (Brook et al. 2010). In 2004, the American Heart Association (AHA) published a scientific statement on the relationship between air pollution and cardiovascular disease. This relationship has - for a long time - been undermined or poorly understood, but is extremely significant, and the AHA argues that, "the cardiovascular health consequences of air pollution generally equal or exceed those due to pulmonary diseases" (Brook et al. 2010). The AHA updated their scientific statement in 2010 to include a "comprehensive review of the new evidence linking PM exposure with cardiovascular disease" targeted at researchers and healthcare providers. It covers epidemiological studies that have found serious adverse health effects from not only long-term exposure (over several months or years), but even over a short term (several hours or days) (Brook et al. 2010).

When exposed to high levels of $PM_{2.5}$ over a short term, there is an elevated risk of acute cardiovascular morbidity and mortality, while over the long term these adverse health effects can reduce life expectancy by over a few years (Brook et al, 2004). Gold et al (2000) found a 69% increase in cardiovascular mortality after short-term exposure to high levels of particulate matter. Especially over the short-term, mortality associated with air pollution is more often related to cardiovascular problems rather than respiratory problems. In Pomona alone, there are 237.9

cardiovascular related deaths per 100,000 population per year, significantly higher than average of 204.8 in Los Angeles County (Los Angeles County Department of Public Health, 2018).

Physical Inactivity, Obesity and Diabetes

Higher levels of air pollution have also been associated with an increase in physical inactivity – a lifestyle factor that is strongly associated with obesity and related health issues such as diabetes and hypertension. According to Centers of Disease Control and Prevention (CDC), the leading cause of death in the United States is heart disease, associated with 647,457 deaths in 2017 (CDC, Fast Stats, Leading, causes of death). The relationship between air pollution, physical inactivity and obesity is complex, but there are several different biological factors that can explain how they interact. Research has demonstrated that higher exposure to $PM_{2.5}$ and other pollutants are associated with higher resting blood pressure and impaired ventilatory function, thereby decreasing exercise capacity (Cakmak et al, 2011). Further explanation of this relationship can be attributed to less walking to and from locations due to poor air quality, its detrimental effects on sleep and an increase in fat intake (Cakmak et al, 2011). Additionally, $PM_{2.5}$ exposure has been linked to an increase in insulin resistance in the human body and adipose inflammation, both adverse health effects that can lead to type-2 diabetes and obesity (Cakmak et al, 2011).

There is a relatively high prevalence obesity and diabetes in the city of Pomona, which should be of great concern, especially in the context of the pandemic and the increased vulnerability of its residents to the novel Corona virus. According to a pre-pandemic survey carried out by the Los Angeles County Department of Public Health in 2015, only 35% of Pomona residents meet the recommended guidelines for physical activity, 31% of residents over the age of 18 are obese - 7% higher than the LA county average and eleven percent were diagnosed with diabetes – approximately 1% higher than the LA county average (Los Angeles County Public Health Department, 2020). Of course, a combination of factors contributes to this high prevalence of obesity among the population including income, food insecurity, and (in)access to parks and green space, but the relationship between heart disease and air pollution might be stronger than initially anticipated and therefore worth exploring.

Cancers

Another important relationship attributed to air pollution is an increase in several different types of cancers in more polluted neighborhoods compared to neighborhoods with cleaner air. Whilst the most widely researched cancer in relation to poor air quality is lung cancer, recent research is finding a link between breast, liver, pancreatic cancers and air pollution (American Association for Cancer Research). A lot of the research on pollutants carried out between 1989 and 1996, during which the relationship between air pollution and adverse health effects was thoroughly explored, were subject to extensive scrutiny for not accounting for individual factors such as smoking when attributing health effects to pollution. These criticisms were not unfounded, as smoking increases relative risk of lung cancer mortality by 14.80 (Pope III, 2002). Whilst the relationship between smoking and lung cancer is undeniably significant, studies since have accounted for individual factors including smoking and have still found a link between ambient air pollution and cancer (Pope III, 2002). In fact, a 10-$\mu g/m^3$ increase in particulate air pollution was found to increase the risk of lung cancer mortality by 8% (Pope III, 2002).

According to the CDC, lung cancer is associated with the most cancer related deaths in the United States, with 24% of cancer deaths being from lung cancer. In the city of Pomona alone, 29.1 of every 100,000 population die from lung cancer, which is higher than the Los

Angeles county average of 27.1, even though a lower percent of the Pomona population smoke compared the Los Angeles average (Los Angeles County Public Health Department, 2020).

Whilst researchers have reached a general understanding that exposure to particulate air pollution, even at relatively low levels, leads to significantly adverse public health impacts, new links between specific diseases and air pollution are continuously being researched, and I have only touched upon the most prominent of these health issues. Understanding the direct link between air pollution and public health is complex, as many diseases can be associated to numerous factors which are difficult to control for. Especially in low-income communities of color whom are faced with multiple burdens of environmental and social injustices, it is often the combination of factors that determine poor public health (Su et al. 2012). However, what is clear from the extensive research conducted on the relationship with air pollution, the detrimental effects of air pollution on public health are significant and deserves further investigation.

Air Pollution, COVID-19 and Comorbidities

The majority of research on the COVID-19 virus so far has focused on what pre-existing health conditions are comorbidities and increase the risk of mortality from the virus. A study carried out in New York looked at the characteristics and comorbidities of hospitalized patients with COVID-19. Of the 5700 hospitalized patients, 57% had hypertension, 42% were obese and 34% had diabetes (Richard et al., 2020). Research has also found that obese individuals are 113% more likely than individuals to be hospitalized, 74% more likely to land in the intensive care unit (ICU), and 48% more likely to die from the virus (Popkin et al. 2020).The reason why obesity and the associated health problems is a high risk factor in serious illness from COVID-19 is because patients suffering from obesity generally have an impaired immunity response and have a reduced lung capacity which makes breathing more difficult (CDC, 2020). In cases of asthma, patients with underlying asthma had a mortality rate of 7.8%, which is significantly higher than those without asthma whom have a mortality rate of 2.8% (Choi, 2020). Asthma weakens lung functioning, which is part of the body that is often hardest hit by COVID-19, which is why people with pre-existing asthma may get more seriously ill from the virus. Lastly, lung cancer is considered another high-risk factor for serious illness from COVID-19. A study carried out with 105 patients who had cancer and tested positive for COVID-19, with 22 of them suffering from lung cancer, found a death rate of 4 (18.8%) and a hospitalization rate of 6 (27.27%) – significantly more severe outcomes than patients without cancer (Dai et al., 2020). Cancer patients, especially those going through chemotherapy, have a compromised immune system and are therefore more vulnerable to falling seriously ill from the virus (NCI, 2020).

The relationship between air pollution and COVID-19 is not surprising, as poor air quality is an environmental factor that is linked to many of the comorbidities of the virus. However, air pollution can also have a more direct impact on rates of transmissions and mortality rates. Inflammation in the throat and lungs caused by acute exposure to pollutants in the airways, make an individual less protected from the virus (Xiao et al., 2020). Research has also found that exposure to air pollution can suppress an early immune response to respiratory illnesses, suggesting that COVID-19 may be harder to detect until later, more advanced stages (Becker, 1999). Overall, air pollution has a significant impact on the disparities of cases and deaths nationally and globally. A recent study published in the journal of Cardiovascular Research found that particulate air pollution ($PM_{2.5}$) has contributed to an estimated 15% of the COVID-19 related deaths world-wide, and 17% in North America (Pozzer et al., 2020). In the United States, neighborhoods that are low income or have a high minority population are burdened with many sources of $PM_{2.5}$ and are harder hit by the pandemic.

Sources of Pollution

A combination of historical, political and social influences has led to the construction of multiple sources of pollution such as freeways and industry in the city of Pomona. Additionally, the location of Pomona and its surrounding geography and topography can also account for possible higher levels of pollution in the city. In this next section, I will be exploring the major sources of pollution that may influence the air quality of the city.

Freeways

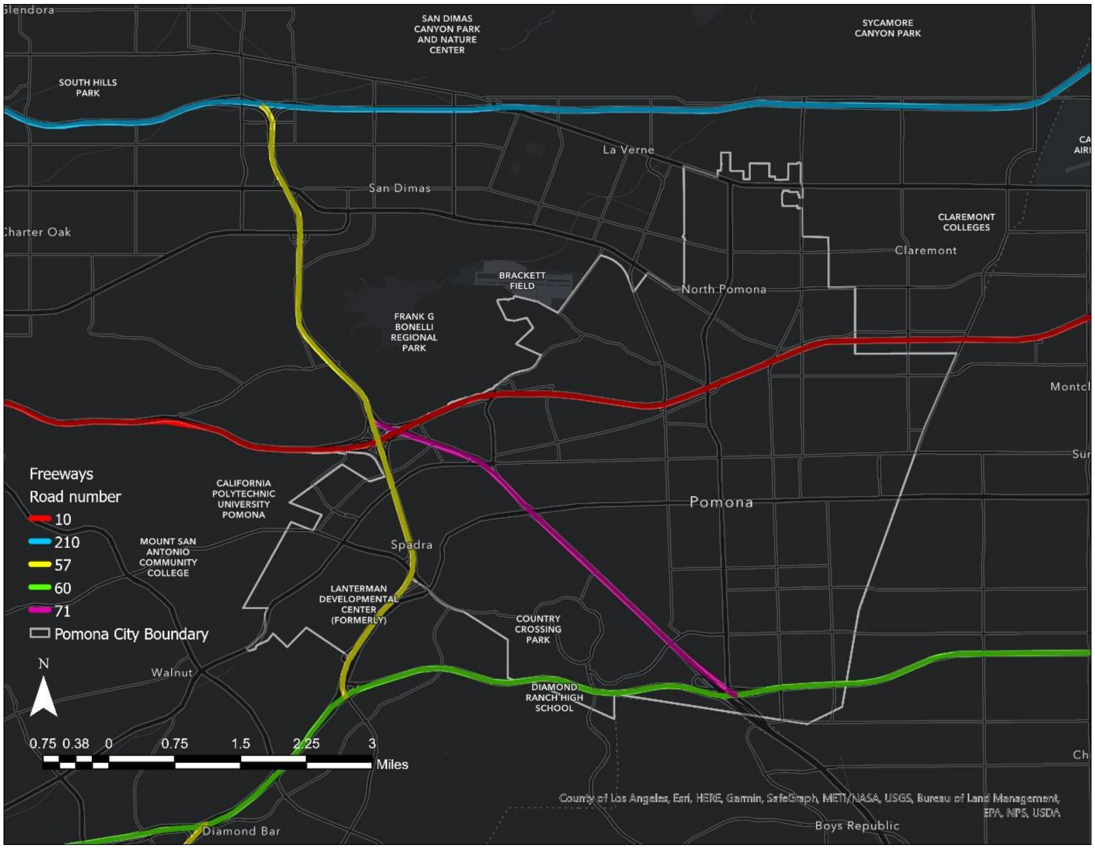

Figure 4. A map showing the 210, 10, 71 and 60 freeways. (Layer Sources: Esri_dm, 2014; Los Angeles GeoHub, 2015)

Research carried out by the Union of Concerned Scientists (UCS), found that residents of Los Angeles are exposed to 60% percent more vehicle-related $PM_{2.5}$ emissions than the state average, and that Latino Californians experience 40% higher levels of the pollutant than white Californians (Reichmuth, 2019). Additionally, low-income communities of color bear twice as much traffic density compared to the rest of the Southern California region (Houston et al, 2004). Vehicle-related pollutants account for the majority of the adverse health impacts in the county, with 70% of the cancer risks being linked to vehicle emissions (Houston et al, 2004).

Five freeways run through portions of the city of Pomona: The 210,10, 71, 60 and the 57, shown of figure 4. This quintet of highways exposes residents of the city to disproportionately high levels of ozone, nitrogen oxide (NOx) and particulate matter, among other pollutants. The San Gabriel Mountains just north of the City of Pomona create a strong mountain-valley wind system which extends the distance that motor vehicle related pollutants can travel (Choi et al., date, 322). In the early morning hours, the air at the top of the mountain cools and flows down the mountain, carrying ultrafine particles and other pollutants into the city. Choi et al. (2012) found that freeway plumes extend significantly further due to this wind flow, exposing residents living within 2km of the freeway to disproportionate amounts of pollutants. In the city of Pomona, a large portion of the residents live within this proximity of a freeway, with the most significant pollution related to these freeway plumes are those areas of Pomona that are nearest to the 210.

Other airborne plumes are the direct result of Pomona industrial economic sector. There is heavy diesel traffic on the five freeways and city streets. Apart from being a major source of sound pollution, heavy diesel traffic poses a major risk to the air quality as they emit exhaust that contains $PM_{2.5}$ among other pollutants. In 2017, residents on Reservoir street in South East Pomona “expressed concern about heavy diesel traffic, truck idling and diesel odors,” (Brown and Rodriguez, 2018) which led to an investigation by the California Air Research Board

(CARB) into the diesel vehicles in the area. Of 300 heavy diesel vehicle inspections carried out at 30 different locations throughout Pomona, 68 were in violation for various reasons including “illegal idling, inadequate emission controls in the vehicles, illegal tampering with emissions controls, and violations of mobile source labeling requirements” (Brown and Rodriguez, 2018). Over half of the citations occurred on Reservoir street, which runs through the Industrial Area in Pomona, where industrial zones and residential homes are located adjacent to each other. In California, heavy duty diesel trucks account for a large part of the daily trips made, and therefore contribute significantly to poor air quality (Houston et al., 2004).

Industrial activity

Figure 5. A Map showing the Industrial Zone in the City of Pomona and 3 fires that have occurred in the area over the past 6 years. Layer Source: (Los Angeles Geohub, 2015).

Another significant source of air pollution in the city of Pomona is from industrial activity. The industrial zone (shown in Figure 5), which takes up most of Southeast Pomona, experiences higher levels of pollutants than other areas of the city due to the industries located in the area.

The major polluting industries in the zone include waste and recycling businesses, with a lot of the larger region's trash being processed in the city, exposing the residents to air pollution and unpleasant odors (Brown and Rodriguez, 2018). There has been a history of poor enforcement of safety and environmental regulations in waste and recycling facilities, but also in the many pallet facilities in the industrial area. In 2014, a major fire broke out at a recycling plant, leaving houses within one-mile radius of the area covered in ash (Cocca, 2014). Four years later, a fire broke out at a pallet facility, also surrounded by residences (Daily Bulletin, 2018). The most recent fire occurred in 2019 in a food waste facility (Daily Bulletin, 2019), which had already been reported for several previous violations in 2016 (Daily Bulletin, 2019). Clean & Green, a grassroots organization "working for greater environmental justice and health in Pomona," (Engdahl, 2017) has fought for years for new regulations to protect Pomona residents from air and other types of pollution. Through pressure from their organization and other organizations like United Voices of Pomona for Environmental Justice, around 150 facilities were inspected in 2017 for environmental compliance, and it was found that 70 of these facilities were in violation (Huynh and Marshall). That same year, Clean & Green proposed a ban on any new waste or recycling facilities in Pomona, which included a ban on the expansion of existing facilities, which was passed without amendment (Daily Bulletin, 2017). The organization now focuses on keeping existing facilities accountable, with a persisting lack of enforcement of regulations in these facilities. The CalEPA Regulated Site Portal (https://siteportal.calepa.ca.gov/nsite/map/results) has detailed information on each of the facilities and their violations.

Topography, Climate and Wildfires

Whilst I am focusing on the city of Pomona specifically, it is important to note that air pollution does not limit itself to city borders, and external factors can also influence levels of pollution within the city. The unique topography of the Los Angeles basin has an impact on the concentrations of air pollutants and where air pollution hotspots are located. A strong afternoon sea breeze from the Pacific coast flows east, carrying with it pollutants from the Los Angeles urban center and freeway emissions into the inland valleys, where Pomona is located (Showstack, 1999). The San Gabriel Mountains that frame the valley to the north trap the air pollutants, and therefore these air pollutants linger near the foothills (Showstack, 1999). Sunlight and high temperatures allow pollutants to react with each other, greatly increasing the levels of secondary pollutants (Teqoya).

Another factor that makes the city more vulnerable to high levels of air pollution are the annual wildfires. Wildfire season typically occurs between May and October in California, but due to climate change and the increase in temperatures the season is starting earlier and ending later in the year (CalFire, 2020). 4.0 million acres have been burnt in 2020, which is the most in recorded history (CalFire, 2020). Wildfires produce significant amounts of gaseous pollutants such as ozone (O_3), carbon monoxide (CO), and nitrogen oxide (NO_x), alongside particulate matter (PM) and epidemiological studies have found a link between wood fire smoke and respiratory infection as it can cause a slowed response in an immune response (Migliaccio et al. 2013), therefore the wildfire season can exacerbate the COVID-19 pandemic. The fires in the 2020 wildfire season have caused the worst air quality in 30 years in California, and the L.A. county public health department issued public health alerts advising people to stay indoors (Stark, 2020). The Bobcat Fire, which started on September 6, 2020 in the San Gabriel

Mountains National Monument and the El Dorado Fire, which started on September 5th in El Dorado park near the San Bernardino national forest, left the city of Pomona 'very unhealthy' air quality (CalFire, 2020).

Air Monitoring in the City

With so many different potential sources of pollution throughout the city, it can be expected that $PM_{2.5}$ levels - among other pollutants - are at unhealthy levels, especially near major roadways and industries. Unfortunately, at this point it is difficult to determine air pollution hotspots within the city due to a lack of monitoring. The nearest active EPA monitoring station to Pomona that measures $PM_{2.5}$ is located in Ontario near the 60 Freeway. The city of Montclair is located between Pomona and Ontario, meaning there is a significant distance between Pomona and the nearest monitor. Although Pomona has its own monitoring station (EPA), it does not currently measure $PM_{2.5}$ levels, so there is a lack of in-city data on $PM_{2.5}$ levels. In this next section, I will discuss the importance of air quality monitoring and examine the current network of air quality monitors and models EPA uses to measure air pollution levels. Additionally, I will discuss why it does not accurately reflect spatial differences of pollutants between neighborhoods, and how low-cost monitors can be utilized to complement, and improve the spatial resolution of existing air pollution data.

Air Monitors: FEM vs Commercially available monitors

Since Congress first passed the Clean Air Act (CAA) in 1963, laws have regulated the release of certain pollutants into the atmosphere. This has made a significant contribution to improving air quality in the United States, and the cumulative benefits are estimated to be at more than $2 trillion in 2020, which substantially surpasses its costs (EPA, 2020). The main purpose of the CAA is “to protect and enhance the quality of the Nation’s air resources so as to promote the public health and welfare and the productive capacity of its population.” (42 U.S.C. 7401). It provides an elaborate regulatory framework to control pollutant emissions from stationary and mobile sources of air pollution and charges the Environmental Protection Agency with the protection of the nation's air quality (EPA, 2020). The CAA amendment in 1990 made the EPA responsible for setting National Ambient Air Quality Standards to regulate the “criteria” air pollutants, otherwise known as the six principal pollutants considered harmful to the public health and environment. Particulate matter is also included in the criteria air pollutants, but the standards for PM were not set until 1997 (EPA, 2020). The annual standard of particle pollution (PM), which is the annual mean concentration averaged over 3 years, is currently set at 12.0 µg/m3 and the 24 hour standard is currently set at 35 µg/m3 (EPA NAAQS table).

Air quality monitoring plays an essential role in effective air quality management systems. In the Integrated Review Plan for the National Ambient Air Quality Standards for Particulate Matter published in 2016, EPA outlines 5 objectives of PM monitoring networks in managing air quality:

1) “Determining compliance with the NAAQS;
2) Characterizing air quality status, including providing the public with timely reports and forecasts of the Air Quality Index (AQI);
3) Supporting air quality analyses used to conduct assessments to exposure, health risks, and welfare effects;
4) Developing and evaluating emissions control strategies;
5) Measuring trends and overall progress for the air pollution control program.” (Jenkins, 2016)

In California, air quality is monitored on a regional scale with 272 active monitors (Coalition for Clean Air, 2020). Due to the high expense and complexity of stationary air monitoring equipment, the spatial resolution of air quality data is relatively low, and monitors are sparsely spread over the state (Wong, 2004). Therefore, modeling systems are used to predict the concentration of criteria pollutants where there are no local stationary monitoring sites. The most common model used by the EPA is the Community Multiscale Air Quality Modeling Systems (CMAQ), which uses a variation of numerical models based on scientific principles to “predict the concentration of airborne gases and particles, and the deposition of these pollutants back to Earth’s surface” with the purpose of providing “fast, technically sound estimates of ozone, particulates, toxics and acid depositions” (EPA, 2020).

Since it uses a combination of software programs and data sources, CMAQ permits users to research a variation of air pollution scenarios. For example, CMAQ can be used to assess the possible impact of future emission regulations on air quality. Some of the existing models used in order to predict concentrations include the Weather Research and Forecasting (WRF) and the Sparse Matrix Operator Kernel Emissions (SMOKE) (EPA, 2020). Weather conditions such as precipitation, temperature and wind direction are important physical driving forces in the atmosphere that can significantly impact the concentrations of pollutants, and it is therefore essential to include in the model through WRF. SMOKE is integrated into the model “to estimate the magnitude and location of pollution sources” (EPA, 2020) through emission profiles. An extensive set of tools are used to turn these emission profiles, which are usually annual or day averages of known emission sources, into data that can be used for air quality modeling (Eyth and Vukovich, 2017).

$PM_{2.5}$ data collected by the EPA monitoring stations is used in combination with the CMAQ model by many different institutions with a wide array of functions. For example, the Center for Disease Control use this method of air quality predicting in their National Environmental Health Tracking Network, a tool that “brings together health data and environment data from national, state, and city sources and provides supporting information to make the data easier to understand” (CDC, National Environmental Public Health Tracking Network). Additionally, CMAQ is used by researchers in order to estimate the public health effects of pollutants from individual sources (Buonocore et al. 2014).

Whilst the Community Multiscale Air Quality model is a widely used model that is continuously being updated and improved, it is important to note the model has some weaknesses. The main difficulty in accurately predicting $PM_{2.5}$ levels is due to the high spatial-variation in the dominant processes that form and remove particulate matter (Yu et al. 2008), therefore, the effectiveness of CMAQ depends on measure of performance, season and location (Bravo et al. 2012). For example, in areas with a complex geography like coastal and mountainous regions CMAQ may be less accurate in estimating pollutant concentrations (EPA. 2020), and CMAQ tends to overestimate $PM_{2.5}$ concentrations in the winter and underestimate concentrations during the summer (Appel et al. 2017). Lastly, a lack of consistency in the metrics used to evaluate model performance makes it hard to (a) compare different model applications and configurations, (b) assess the efficacy on updates on the model compared to previous versions of the model, (c) sufficiently inform users on the uncertainty and weaknesses in the model before using the information in decision making (Emery et al. 2017).

As a response to the relatively low spatial resolution of air quality data, researchers have turned to more towards Community Based Participatory Research (CBPR), an approach which tackles issues or air pollution at a local level whilst involving community members in the research process (Commodore et al., 2017). This comes with the general trend in science in embracing community science (Hiegl et al. 2019), which is defined as “the practice of public participation and collaboration in scientific research to increase scientific knowledge” (Ullrich, 2012). Over the years, technology used to collect air quality data has become cheaper and more accessible - even to the general public (Hasenfratz, 2012). Several studies have already adopted a participatory approach in their data collection. For example, Quinn et al. (2018) used wearable automated microenvironmental aerosol samplers (AMAS) to measure $PM_{2.5}$ exposure for 25 high school students in Fresno. Another study used Portable $PM_{2.5}$ sensors in wearable packs to measure personal daily exposure of participants in five cities in the Inland Empire region of Southern California (Do et al. 2020). The unintrusive nature of these small sensors allowed participants to go about their day without interruption, allowing the monitors to track their location and their personal exposure throughout their day – which is much harder to do with stationary monitors.

The Changing Paradigm of Air Pollution Monitoring, an article published in Environmental Science and Technology, outlines four potential uses for the low-cost, easy to use sensor technology; "(1) supplementing routine ambient air monitoring networks, (2) expanding the conversations with communities, (3) enhancing source compliance monitoring, and (4) monitoring personal exposures." (Snyder et al, 2013). There are already several community-focused initiatives that are utilizing low-cost sensors to make air quality monitoring more accessible to the public for uses beyond just for research purposes. For example, PurpleAir is a Utah-based company which manufactures relatively inexpensive air quality monitoring technology available for purchase to the public (PurpleAir). I will use PurpleAir as a case study to demonstrate how companies are embracing the uses of the new censoring technologies.

Research into the distribution of air pollution has found a high spatial and temporal variability in the concentration of pollutants, meaning that pollutant concentration can vary greatly between cities, and even neighborhoods (Yu et al. 2008). Since EPA's current ambient air monitoring network is sparse, air quality data collected by the monitors have a low spatial resolution and have difficulty detecting pollutants at a neighborhood level. This has exposed the need for supplemental air monitoring besides the official EPA monitors. PurpleAir offers low-cost, user friendly air quality monitors called PA-II that are available to the general public. When purchased, the user installs the device in a location of choice (indoors or outdoors), and once connected the monitor starts collecting air quality data. PurpleAir crowdsources the data from all their monitors and makes this information available to the public through a real-time air quality map which shows the location and calculated AQI (air quality index) of each of the monitors (TWiT Tech Podcast Network, 2018). Currently, there are 10,000 functioning PA-II monitors worldwide, many of them located in areas that have no official air quality monitoring (Ardon-Dryer et al. 2020).

Initiatives like PurpleAir allow community residents to monitor air quality in the places they live and work, and therefore are directly impacted by. Most users of the PA-II are individuals who are interested, and often concerned, about the air quality in their neighborhood, and place their monitors near their residence for very localized data (PurpleAir). These monitors can even detect point-sources of pollutants which distant AQMS monitors are unable to pick up on - for example - a monitor located by residences in proximity to an industrial site might be able to detect higher concentrations of pollutants that are emitted by that industry (Stewert, 2019). As all data collected is public, not only is the individual familiarized with the air quality in their area, but it also informs the entire surrounding community by giving neighborhood-level information that AQMS monitors fail to capture. For example, during the 2020 wildfire season in Southern California, which proved to be particularly devastating (Stark, 2020), many

Californians turned to PurpleAir for real-time air quality data within their local neighborhood (Peters, 2020).

Industries and city governments can also make use of PA-II monitors for source-compliance monitoring. Fence-line monitoring, where a sensor is placed in close proximity to an industrial site, or in-plant monitoring, where a sensor is placed within a factory or plant, can ensure that industrial activities do not violate emission rules and regulations, protecting workers and surrounding communities from the detrimental health effects of over-exposure to pollutants.

Initiatives like PurpleAir are a promising glimpse into a future where individuals engage in the collection of data that drives decision making in their communities, giving them more control into what happens in their environment. Low-cost sensor monitors are already being included in the concept of a smart city - defined as "a framework predominantly composed of Information and Communication Technologies (ICT), to develop, deploy, and promote sustainable development practices to address growing urbanization challenges" (Thales, 2020). An extensive network of low-cost, portable monitoring, along with the capabilities of 'Big Data' such as machine learning to citizens to understand the fluctuations in pollutant concentrations that they are exposed to in their daily lives, and even allows future predictions in concentrations (GSMA, 2018). This has become increasingly more important in a world where "98% of cities in low- and middle-income countries with more than 100 000 inhabitants do not meet WHO air quality guidelines", and 56% of those cities in high-income countries (WHO, 2016).

However, one of the greatest concerns related to the implementation of these low-cost sensors is the question of their accuracy. AQMs monitors have to follow the Federal Reference Method (FRM) or the Federal Equivalent Method (FEM) to comply with air pollution standards. Commercially available, low-cost monitors do not necessarily have to comply with these methods, which is a benefit in that this allows the product to be cheaper and the sensors are not – limited in the situations they can be used (Lane Regional Air Protection Agency, 2018). Unfortunately, this also means they have not been sufficiently assessed in different weather conditions and air pollution events (Snyder et al. 2013). Whilst I will go through the specific accuracy issues associated with the PMS5003 sensor—the sensor I will be using in my own research—it is true for consumer-grade monitors across the board that they are not yet as reliable as FEM grade sensors (Luongo, 2018). This is of course due to the fact that they are held to less vigorous standards and because many of these monitors are relatively new technologies that have not yet been used in research to the same extent as FEM monitors.

PMS5003

The PMS5003 is a popular low-cost air quality sensor produced by Plantower, a firm based in China that is involved with the research and development of air quality technologies. Companies such as PurpleAir and the Air Quality Egg make use of the PMS5003 sensors in their own monitors. This match-box sized monitor uses the light scattering principle to measure the concentration and composition of air pollutants. Light scattering measures the size of particles based on the light scattering pattern of the air samples when illuminated with a laser beam. Emitted light can move in different directions depending on the size of the particle, and light scattering generally increases as there are higher levels of particulate matter (Luongo, 2018). The scattered light is detected by a photodiode in the sensor and converted into particle count and mass concentration values (Lattanzio).

This low-cost monitor has been evaluated in several studies with varying levels of success. A study published in Atmospheric Measurements Technique found that PA-II monitors—which uses two PMS5003 sensors—and the AQMs monitors were generally in agreement with each other as they detected similar trends in $PM_{2.5}$ concentrations. However, they found that the PA-II showed slightly higher concentrations of $PM_{2.5}$ during high-pollution events (Ardon-Dryer et al. 2020). Sayahi et al. (2019) found that the PMS5003 sensors were most in accord with the AQMs sensors during winter months, and therefore that there are seasonal differences in sensor performance. Bi et al. (2020) found that high temperatures and higher levels of humidity also impacted sensor performance, along with longevity of use. We must keep into consideration that most low-cost sensors, including PMS5003, are only calibrated once during production, whilst FEM monitors such as AQMs monitors are calibrated about twice a year by the EPA standards (TWiT Tech Podcast Network, 2018). However, there is agreement that these monitors can be used to "better reflect $PM_{2.5}$ spatial details and hotspots" (Bi et al. 2020), especially in collaboration with AQMs monitors.

Spatial Differences in $PM_{2.5}$ Concentrations in Pomona Neighborhoods: A Pilot Study

The intention of this pilot study is to demonstrate the spatial variation in $PM_{2.5}$ levels within the city of Pomona, and to explore whether low-income, Latino neighborhoods in Pomona are exposed to higher concentrations of the pollutant. In the following section, I will go through the methods and results of my air quality study and then I will discuss the implications of my study within the wider context of spatial injustice in this Southern California city.

Methods

For this study, I placed air quality monitors outside residences of participants in different locations of the city and measured outdoor $PM_{2.5}$ concentrations for a week. To conduct these measurements, I deployed PM5003 air quality monitors in 7 different sites. I selected the PM5003 monitor because it has been utilized and evaluated in previous air quality studies

(Ardon-Dryer et al., 2020; Bi et al., 2020; Sayahi et al., 2019). In addition, the low cost of the technology has allowed me to use numerous monitors within a reasonable budget. The monitor is connected to a Raspberry Pi Zero W board, which has been programmed to monitor environmental air quality using a python code. The code ensures that the monitor measures the $PM_{2.5}$ concentration in the immediate surroundings every 10 minutes, and the measurements are recorded in a comma-separated value (csv) file which can then be processed for data analysis (Los Huertos et al. 2020). For this particular study, the first set of monitors recorded $PM_{2.5}$ concentrations from Friday 2/12/2021 to Thursday 2/18/2021, while the second set of monitors recorded from Friday 2/26 to Thursday 3/2.

I used snowball samplings for this study by reaching out to grassroot organizations and local community groups. I found people who showed interest in the issue of air pollution in Pomona who would be willing to have a monitor outside their residence for a week.

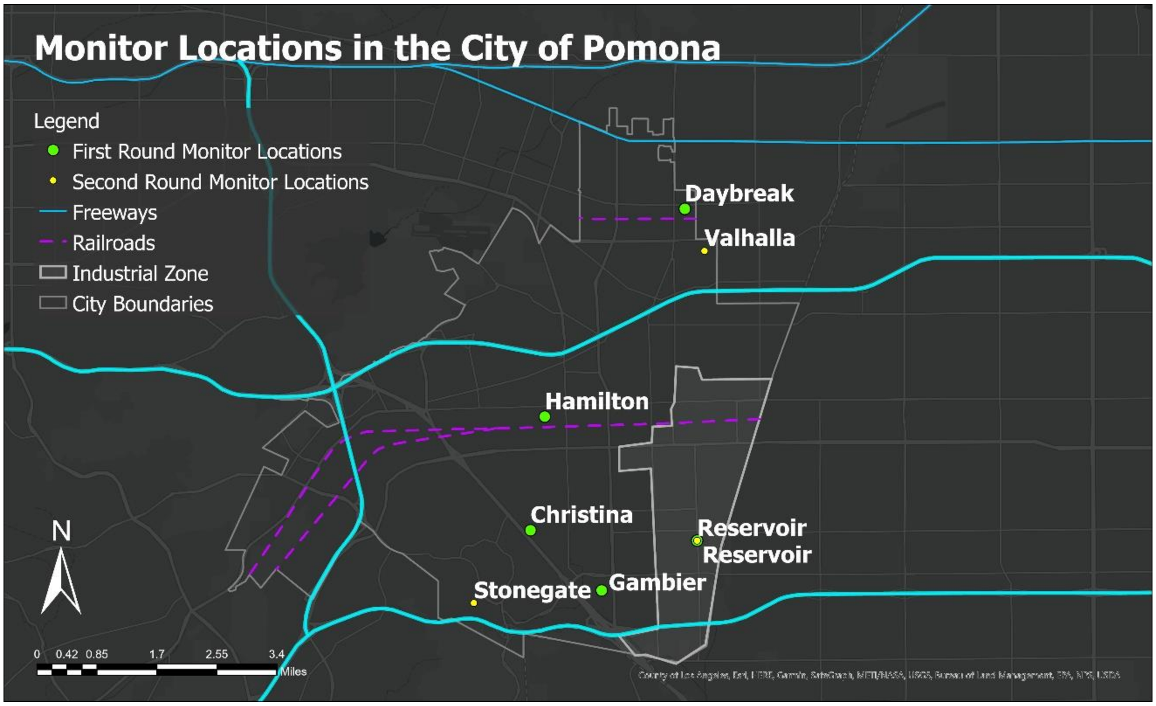

Figure 6. Map demonstrating the location of first and second round monitors. Layer Sources: (Esri_dm, 2015)

Within the sample, I selected participants based on their location in order to best represent neighborhoods with varying proximity to potential sources of pollution (eg. freeway, industry, railroads etc.).

Since I am looking specifically at the exposure to $PM_{2.5}$ in residents of the city of Pomona, I selected areas with predominantly residential development, or mixed land-use including residential development. The study was carried out in two rounds due to availability of monitors and locations at different moments of time. I placed a monitor on Reservoir street in both rounds as it has been identified by local grassroot organizations, including Clean and Green Pomona and United Voices of Pomona for Environmental Justice, as a significant area of concern for air pollution due to the industrial land use directly adjacent to residences, and the heavy diesel traffic that utilizes that street to access local industries or as a route between CA 60 and neighboring cities.

Location Descriptions

Monitor Location	**Description**	**Median Household Income of Census Tract ($)**	**Percent of Population in Census Tract that is Latino (%)**
Reservoir	A street running through two parallel land uses: residential land use and industrial land use. Adjacent to a heavy-duty trucking school.	56,667	79.4
Gambier	This location is approximately 1000 ft. east from the CA 71 freeway, in a predominantly residential area.	62,300	85.6
Christina	This location is within 500 ft. east from the CA 71 freeway, in a predominantly residential area.	62,300	85.6

Hamilton	Within 1000 ft. north of the Union Pacific railroad, in a predominantly residential area but in proximity to several auto repair shops. Adjacent to a small park.	40,562	88
Daybreak	Within 500 ft. north of the Metrolink (Santa Fe) railroad. Only location in the first round of Monitoring that is North of the 10 freeway.	74,164	60

Table 1. Description of Individual Locations – First Round of Monitors

Monitor Location	**Description**	**Median Household Income of Census Tract ($)**	**Percent of Population in Census Tract that is Latino (%)**
Reservoir	A street running through two parallel land uses: residential land use and industrial land use. Adjacent to a heavy-duty trucking school.	56,667	79.4
Valhalla	A predominantly residential area north of the 10 freeway. Near the 10 freeway but not within 1000 ft.	77,026	78.9
Stonegate	A predominantly residential area within 1000 ft. north of the 60 freeway. In proximity to a large park with green space.	107,208	32.3

Table 2. Description of Individual Locations – Second Round of Monitors.

Data Analysis

Since monitors were turned on and off at different times, I cut data sets from each location to represent the same time span to allow for statistical analysis. The mean, standard deviation and quartiles were calculated for each dataset. To explore the variation in $PM_{2.5}$ concentrations within the city, I carried out an analysis of variance (ANOVA) test with data collected from each location to see if there was a significant difference between them. Since the two groups of monitors were not measuring over the same week, I ran a separate ANOVA for each group. I also ran linear regression models along with independent two sample t-tests to examine the relationship between median household income, Latino population per census tract and mean $PM_{2.5}$ concentrations. I selected percentage of Latino population per census tract as a variable as they represent the largest population in the city, with 71.7% of the Pomona's residents being of Latino descent, with white, non-Latino, Asians, and Blacks following at 10.8%, 10.1%, and 5.3 respectively (World Population Review, 2021).

Results

Location	**Mean $PM_{2.5}$ concentration (μg/m³)**	**Standard Deviation (μg/m³)**	**Upper Quartile (μg/m³)**	**Lower Quartile (μg/m³)**
Christina	16.10	21.90	21	6
Hamilton	15.81	13.53	20	6
Daybreak	10.42	21.14	13	5
Gambier	16.49	12.62	23	7
Reservoir (1)	16.92	13.68	23	7

Table 3. Statistical Analysis Group 1 Monitors

Location	Mean $PM_{2.5}$ concentration (µg/m³)	Standard Deviation (µg/m³)	Upper Quartile (µg/m³)	Lower Quartile (µg/m³)
Stonegate	9.38	8.59	13	3
Valhalla	7.73	7.00	11	2
Reservoir (2)	14.45	15.60	20	4

Table 4. Statistical Analysis Group 2 Monitors

Within the first round of monitors, the monitor on Reservoir street showed the highest mean $PM_{2.5}$ concentrations (16.92 µg/m³), which was only slightly above the means of Gambier drive (16.49 µg/m³), Christina court (16.10 µg/m³) and Hamilton boulevard (15.81 µg/m³). Daybreak showed significantly lower concentrations of $PM_{2.5}$, with a mean concentration of 10.42 µg/m³. When an ANOVA test was run with all group 1 data sets, the calculated F-value was 9.98e-10, which suggests there is a significant difference between datasets. However, when a separate ANOVA test was run without the Daybreak data set, the F-value was 0.861, meaning there is no significant difference between the Reservoir, Gambier, Christina and Hamilton datasets. The Christina and Daybreak monitors showed higher standard deviation than the other locations, with a standard deviation of 21.9 µg/m³ and 21.14 µg/m³ respectively. The linear regression model shows a negative relationship between housing income and $PM_{2.5}$ levels, and the p-value of the t-test was 0.0005, suggesting that this relationship is significant. There was a positive relationship between percent of Latino population per census tract and $PM_{2.5}$ level, with a p-value of 0.0001.

Within the second round of data gathering, the monitor of Reservoir street once again showed the highest mean in $PM_{2.5}$ concentrations (14.45 µg/m³), which was significantly higher than the means in Stonegate (9.38 µg/m³) and Valhalla (7.73 µg/m³). The ANOVA test carried out on these three data sets calculated an F-value of $1.5e^{-07}$, suggesting a significant difference in the $PM_{2.5}$ concentrations between the locations. The linear regression model shows a positive relationship between housing income and $PM_{2.5}$ levels, with a t-test p-value of 0.03, again suggesting a significant relationship between the two variables. Within this group, there is a positive relationship between percent of Latino population per census tract and $PM_{2.5}$ level, with a significant p-value of 0.04.

Graphs - Group 1

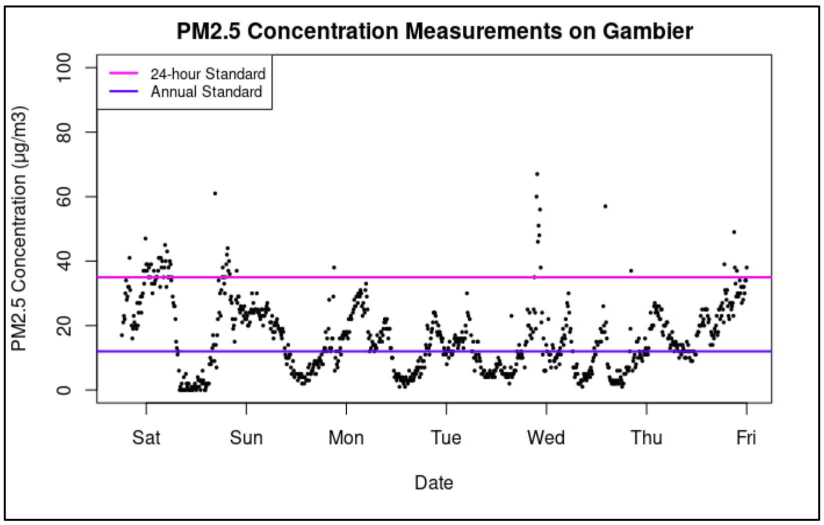

Figure 7. Graph showing $PM_{2.5}$ concentrations on Gambier

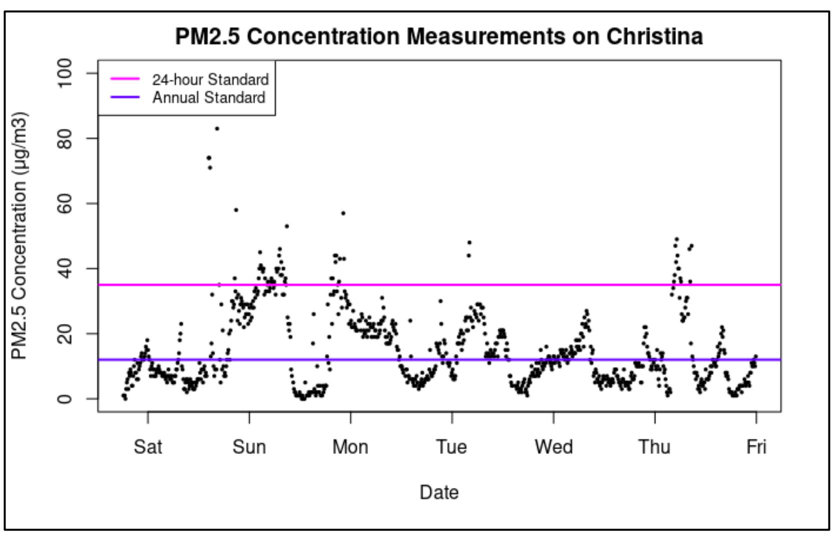

Figure 8. Graph showing $PM_{2.5}$ concentrations on Christina

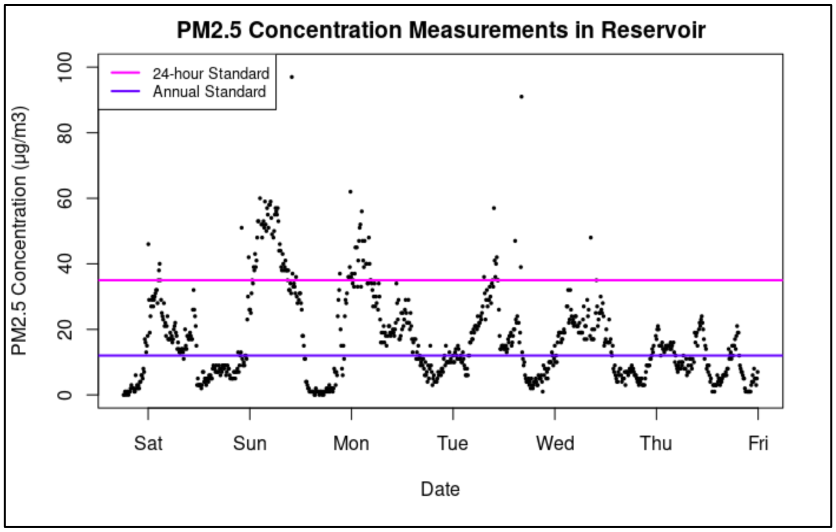

Figure 9. Graph showing $PM_{2.5}$ concentrations on Reservoir

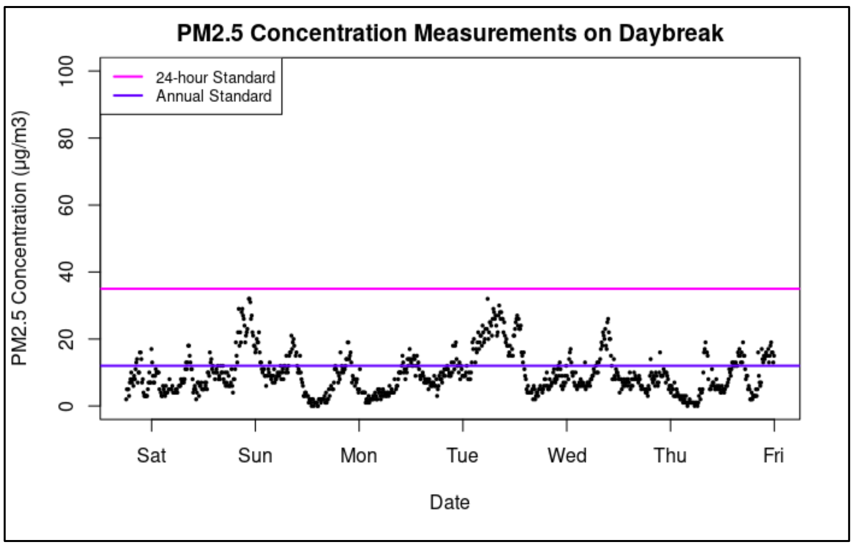

Figure 10. Graph showing $PM_{2.5}$ concentrations on Daybreak

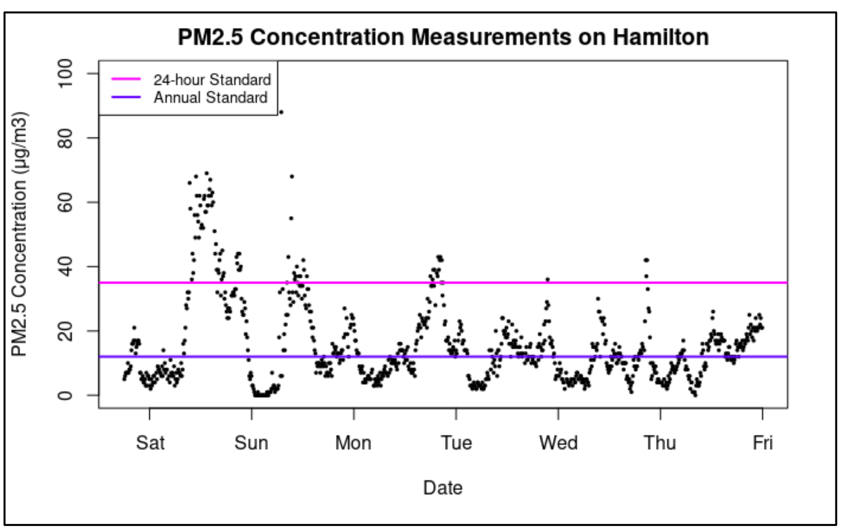

Figure 11. Graph showing $PM_{2.5}$ concentrations on Hamilton

Group 2 Graphs

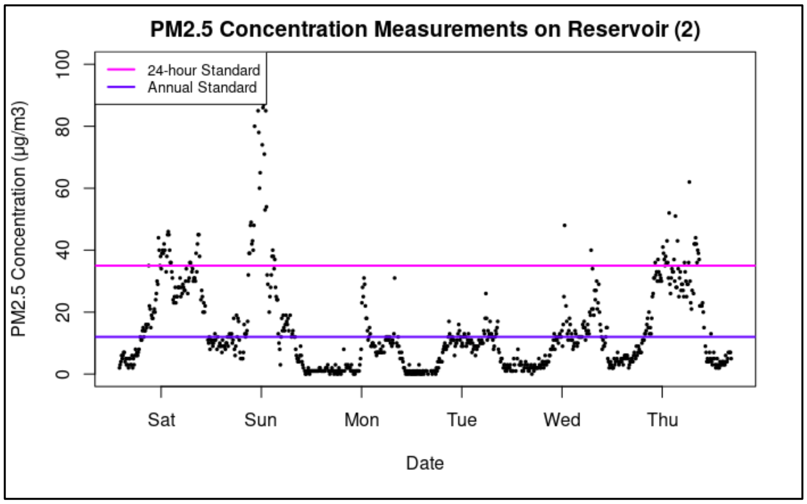

Figure 12. Graph showing $PM_{2.5}$ concentrations on Reservoir (Second Round)

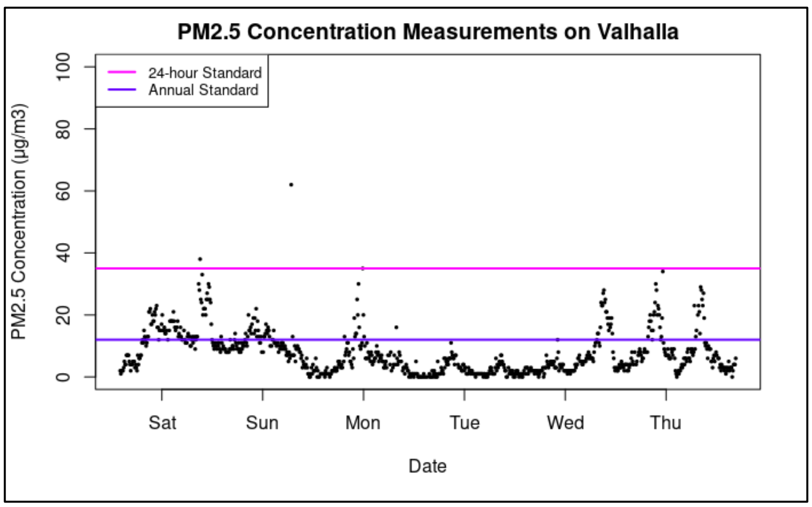

Figure 13. Graph showing $PM_{2.5}$ concentrations on Valhalla

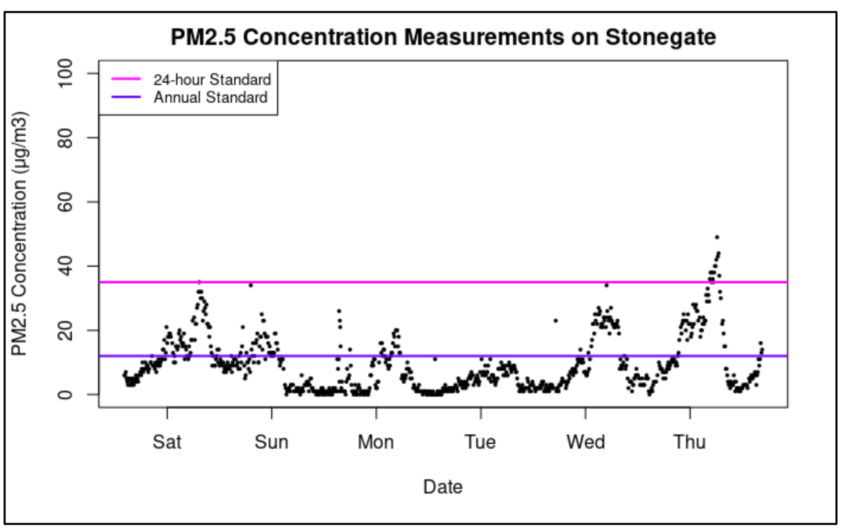

Figure 14. Graph showing $PM_{2.5}$ concentrations on Stonegate

Discussion

Since there is a statistically significant difference found between data sets in both groups, I conclude that there is a variation in $PM_{2.5}$ levels within the city of Pomona. This suggests that having one air monitor in the city would not sufficiently represent the spatial variation in particulate matter concentrations in all neighborhoods. Reservoir has the highest $PM_{2.5}$ concentrations among both groups, which aligns with local grassroots' concern for that particular area. With this street being a designated truck route (Márquez, 2019), and providing access to industries known to violate environmental regulations (CalEPA), it is unsurprising that the mean $PM_{2.5}$ concentration in this area surpasses the annual EPA standard; or that it regularly reaches levels as high as 50 $\mu g/m^3$, which is considerably higher than the EPA 24-hour standard of 35 $\mu g/m^3$. With serious health impacts occurring even at short-term exposure, and with the PM-related mortality increasing by 2.8% for every 10 $\mu g/m^3$ increase of $PM_{2.5}$ concentrations, the air pollution level on Reservoir is clearly an issue that needs to be addressed.

That said, Hamilton, Gambier and Christina, which are all located south of the I-10 freeway, have very similar concentrations of $PM_{2.5}$ as Reservoir, and relatively higher concentrations than monitors located in North Pomona. Daybreak is the only location in Group One that has significantly lower $PM_{2.5}$ measurements than the other four locations with 10.42 $\mu g/m^3$. In Group Two, Valhalla shows the lowest concentrations with 7.73 $\mu g/m^3$. Daybreak and Valhalla are the only two monitors located north of I-10, with all the other monitors located south of that high-traffic freeway. The higher $PM_{2.5}$ concentrations south of the freeway may be associated with the San Gabriel mountain-valley wind system that travels from north to south, meaning that the vehicle-related pollution emitted from traffic on the 10 freeway could be carried down into the southern areas of the city.

The significant differences in particulate matter concentrations north and south of the freeway suggests that the 10 freeway is a major contributor to pollution in the southern parts of Pomona. The I-10 has the highest traffic count of all the freeways passing through the city, with an annual average daily traffic (AADT) of 246,000 vehicles, compared to the AADT counts of 217,000 vehicles on the CA 60, 159,000 on the CA 210, 154,000 on the CA 57, and 80,000 on the CA 71 (Esri, 2020). Higher traffic volume is associated with higher levels of pollution, which could explain why the I-10 has such a significant impact on air quality (Rakowska, 2014). In addition, I-10 is an important commercial route—40% of goods consumed in the United States arrive through the port of Los Angeles, and the I-10 is one of the main roads to transport goods to other parts of the country (Gersema, 2015). Therefore, a large portion of the traffic is heavy-duty diesel traffic carrying goods. In fact, Guiliano and O'Brian (2009), found that heavy-diesel trucks represented 12-14% of the total traffic on major freeways serving Southern California ports, while they accounted for only 2-3% of traffic on other freeways in the region. Heavy-diesel trucks are known to be a major source of the pollutant nitrogen oxide (Dennis, 2020), as well as black carbon, a component of particulate matter (Kimbrough et al. 2018).

In addition, numerous warehouses, industry and truck stops in cities neighboring Interstate 10 brings heavy-duty traffic into neighborhoods (Scauzillo, 2019), which, in the case of the city of Pomona, are predominantly located on its south side. The spatial patterns between north and south of the freeway do not stop there. We see that census tracts south of the freeway have lower household incomes and a higher Latino population (Figure 15).

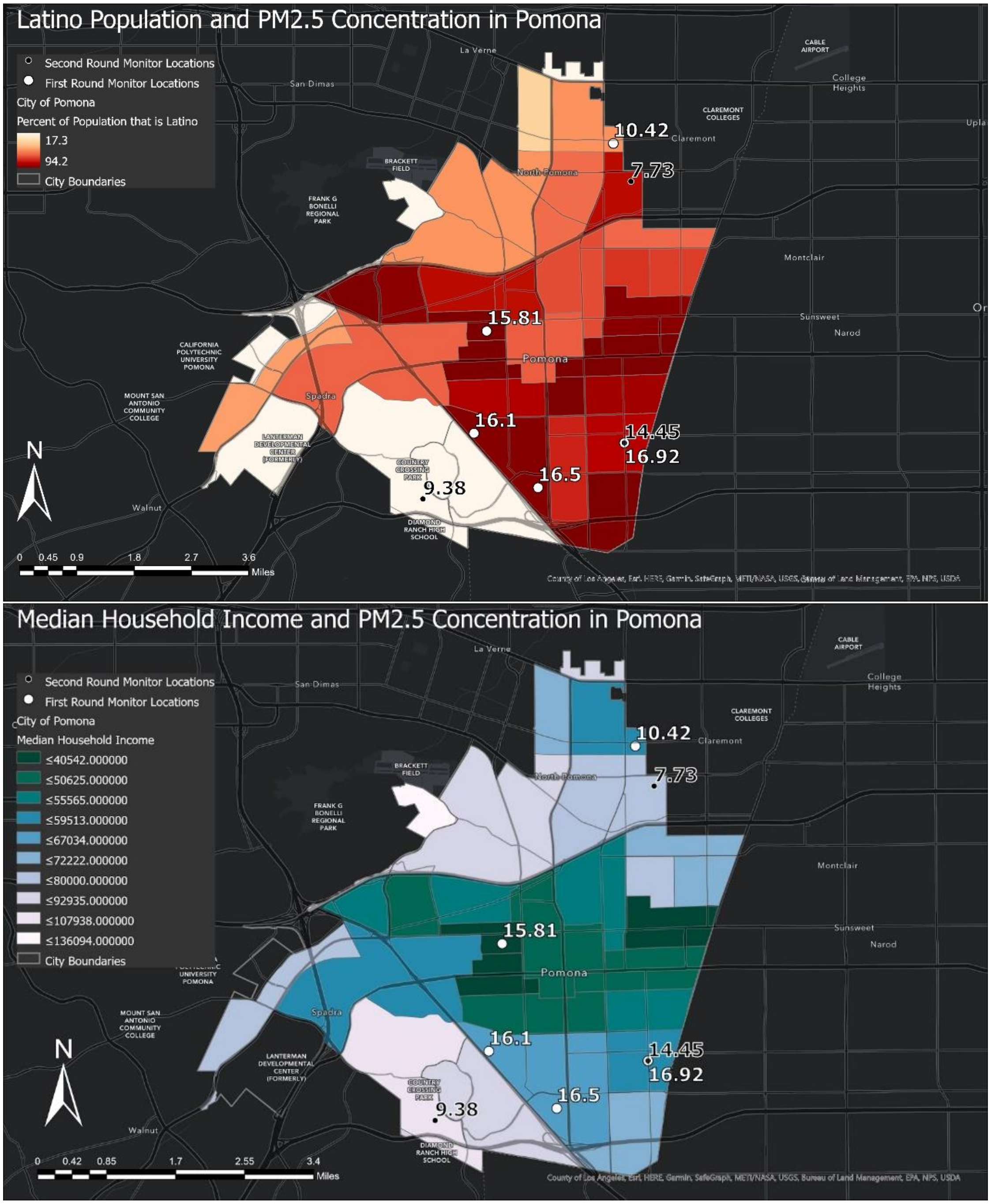

Figure 15. Maps showing spatial patterns of Latino Population (Top) and Median Household Income (Bottom) in the city of Pomona. Layer Sources: (Esri, 2018; Esri, 2020)

This follows the historical patterns of segregation similar to the racial segregation of the citrus industry and the redlining-maps of the 1930s, where Southern parts of the city were labelled by the HOLC with red or yellow grades because of the high Mexican population and poorer living conditions. Whilst this separation was initially marked the Union railroad, it seems that the 10 freeway marks the new boundary between the wealthier, non-Latino, whiter areas of the city and the lower-income, Latino areas.

Phillips Ranch, however, is an exception to this pattern. Despite being located in south Pomona, it is markedly different from the rest of the South communities. It is one of the few areas in the city where Latinos do not account for the majority of the population, and the average household income is over $100,000 (Esri, 2020) - significantly higher than the average median household income in the city, which is $55,115 (Data USA, 2021).

The CA 71 freeway separates it from the lower-income areas of South Pomona, and this wealthier part of Pomona benefits from absence of industrial development, which contributes significantly to cleaner air quality. The predominantly residential and recreational land use instead of industrial land use has an impact on the type of traffic that runs through, and heavy-diesel traffic is far less common in the area. In fact, there are no designated truck routes that run through Phillips Ranch, so trucks are not permitted to travel through this neighborhood.

While the majority of Pomona’s neighborhoods lack access to greenspace (The Los Angeles Department of Public Health, 2018), Phillips Ranch is one of the greener areas in Pomona, as is evident from the land use map of the city (Figure 16). Apart from the Phillips Ranch park and Riparian Green Belt, both public green spaces, a large portion of the neighborhood’s roads are lined and residential yards covered by trees and vegetation. Research suggests that higher green space coverage is associated with lower daily mean, maximum and minimum $PM_{2.5}$ concentration (Chen et al., 2019) .While it is unclear how significant the impact of trees and vegetation is on air pollution levels, studies have found lower prevalence of lung cancer (Wang et al., 2016) and asthma in children (Lovasi et al., 2008) with higher tree density, which are health conditions commonly associated with poor air quality. Phillips Ranch has a CalEnviroscreen Ranking of 43 for asthma and 32 for cardiovascular issues, in contrast to most South Pomona census tracts that have an asthma score of 79 and cardiovascular score of 77, indicating that Phillips Ranch has significantly lower prevalence of these air pollution-related health problems than in the rest of South Pomona.

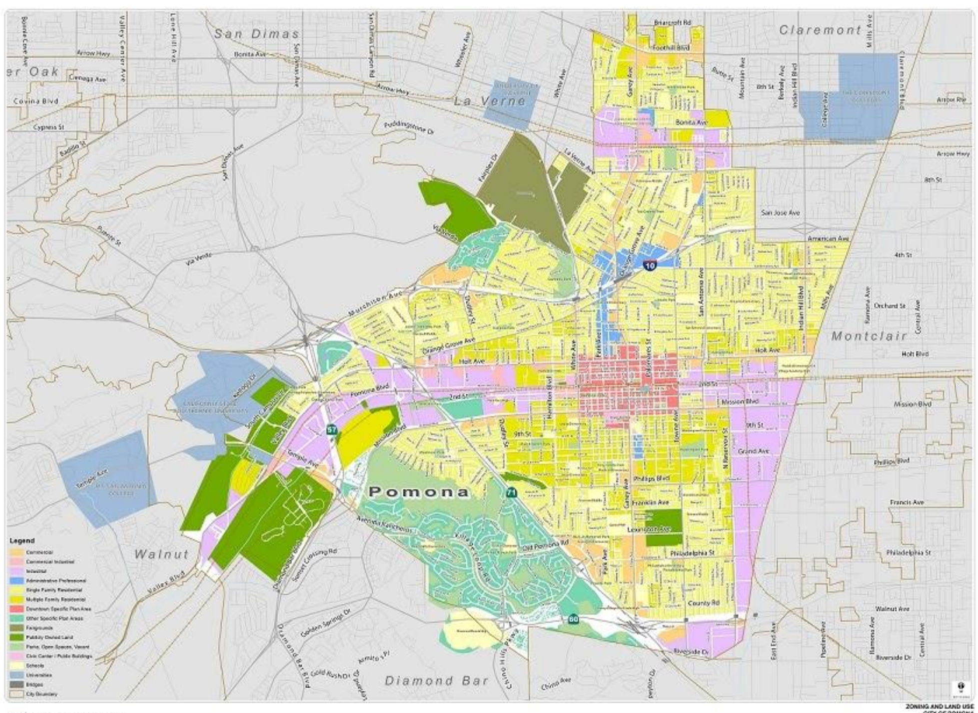

Figure 16. Map of Land Use in the City of Pomona. (Source: City of Pomona)

The differences in $PM_{2.5}$ concentration between richer, whiter neighborhoods and poorer, Latino neighborhoods, and the disparate prevalence of health problems that are associated with this pollutant, points to an environmental justice issue linked to historical social injustices that has shaped the spatial segregation in the city. South Pomona has historically been a target of polluting industrial activities from waste, recycling, and pallet facilities. In addition, there has been a lack of investment into resources and facilities that improve residents' lifestyle such as green spaces in these parts of the city. However, developers and the city have invested heavily in Phillips Ranch - a richer, whiter community which was founded with an attempt to “balance out the population” (The Los Angeles Times, 1978). Despite the economic and spatial growth that has occurred in South Pomona over the decades, it is essential to recognize that there are still hints of a legacy of segregation, with not only an economic and racial separation, but also evidently within the disparities in who carries the most environmental burden. As sources of pollution are predominantly located in the lower-income Latino neighborhoods who already experience multiple social and economic burdens, these communities are now exposed to high levels of pollutants that are known to damage human health.

Limitations

There are several limitations to this study that are important to acknowledge. Firstly, the small sample size reduces the power of the statistical analysis and could therefore make the results more prone to a type II error, which occurs when a researcher fails to reject a null hypothesis which is in fact false. Future studies looking into the spatial differences in $PM_{2.5}$ in the city of Pomona should include a larger sample size to see whether the results of this study are replicable. The use of more monitors would allow for better insight into concentration variation between neighborhoods. I would encourage further research to focus especially on the impacts of proximity to freeways and truck routes and the location of residents upwind or downwind, as my research suggests that vehicle emissions is a significant factor in spatial differences within the city.

Another important limitation is that the time period in which $PM_{2.5}$ concentrations was measured was relatively short, which might not accurately depict differing temporal patterns in $PM_{2.5}$. For example, when I initially tested functionality of the monitors in November 2020, I collected five-days-worth of data from Reservoir which showed much higher levels of $PM_{2.5}$ concentrations than the data is collected during this pilot study which occurred from November 1st to 6th with a mean $PM_{2.5}$ concentration of 33.56 µg/m³, suggesting that the air quality may vary depending on the time of the year. Figure 17 shows the graph of the data collected over those days, with $PM_{2.5}$ clearly violating EPA standards.

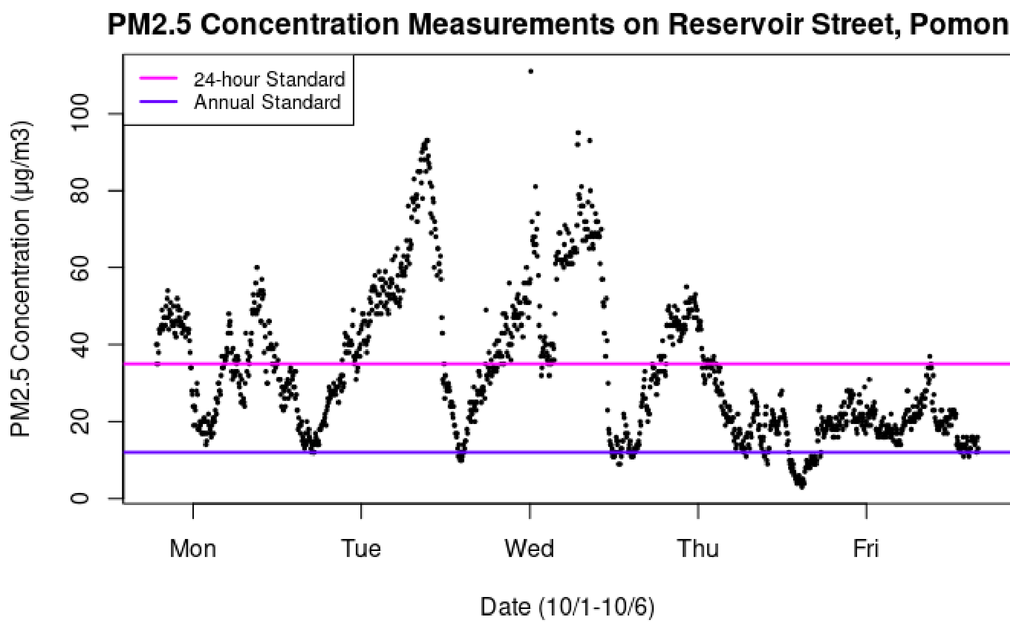

Figure 17. Graph showing $PM_{2.5}$ concentrations on Reservoir between 10/1-10/6

Research has found higher $PM_{2.5}$ levels in California during the winter months (November to February) than during Summer months (June-September). This is due to colder temperatures, lower wind speeds, and low inversion layers, which “favors the formation of NO3- and SO42-” (Motabelli et al. 2003), both significant components of $PM_{2.5}$. Another seasonal factor that may contribute to high pollution events are the two distinct wildfire seasons—the first of which runs from October to April during the Santa Ana wind events, or during the hot, dry season of June to September (Jin et al. 2015). A follow-up study should be carried out over a longer period of time to account for temporal differences and whether neighborhoods in south Pomona experience higher $PM_{2.5}$ concentrations during high pollution events due to their position downwind.

Other factors that are beyond the scope of my study that could account for spatial variation in $PM_{2.5}$ are geographical differences such as elevation or vertical distance from pollution sources, road structures, and population density. In addition, since the monitors I used were fixed in one location, the study does not accurately represent the actual exposure that residents experience in their day to day lives. To better understand how air pollution exposure is impacting residents living and working in Pomona, a personal exposure study should be carried out with portable monitors that can be carried around throughout the day.

Recommendations

It is well-established that Los Angeles county, along the Southern California region in general, suffers from some of the worst air quality in the nation. However, the disproportionate patterns of exposure to air pollutants that give rise to an array of adverse health impacts in low-income communities of color often stay hidden. An absence of neighborhood-level air quality monitoring, along with weak enforcement of air-quality regulations, has left many communities like those in South Pomona vulnerable to the detrimental effects of $PM_{2.5}$, with little action taken to improve the situation. In the next section, I will outline recommendations at a regional and local level on how to address this issue from an environmental justice standpoint that takes both the spatial and social factors of air quality into account.

State-wide Policies, Programs and Incentives

Seeing as on-road vehicle-related emissions, especially resulting from freeway traffic, are a significant source of air pollution in the city, state-wide regulations targeted at heavy-duty diesel traffic may be an effective strategy in addressing the air quality issue. According to CARB, on-road emissions in the Southern California region "are expected to decline significantly from 2017 to 2024, due to turnover to cleaner vehicles for both light-duty vehicles and heavy-duty trucks" (SCAQMD, 2019). This is great news for communities like Pomona in proximity to one or several major freeways. That being said, $PM_{2.5}$ emissions from heavy-duty trucks are projected to increase slightly because of an expected rise in heavy-truck activity, and therefore "overall $PM_{2.5}$ emissions from vehicles are projected to grow by 1 ton/year from 2024 to 2029" (SCAQMD, 2019). Regulations and incentives targeting specifically heavy-duty diesel emissions in the Southern California region, due to an increase of freight activity, are necessary to mitigate the impacts of freight pollution in communities in this area.

EPA, CARB and SCAQMD are responsible for statewide emission reduction, and already have several programs aimed specifically at trucks. EPA, in 2018, adopted the Cleaner Trucks Initiative (CTI) to "update NOx emissions standards for heavy-duty trucks" and "to reduce particulate matter and ozone" (EPA, 2018). Working to identify cleaner technologies for heavy-duty trucks, EPA are basing new NOx emission standards on these technologies to strongly encourage industries to buy cleaner trucks or retrofit their existing vehicles (EPA, 2018). In addition, South Coast AQMD established the Carl Moyer program, which "provides financial incentives to assist in the purchase of cleaner-than-required engine and equipment technologies" (SCAQMD), with the Voucher Incentive Program (VIP) being of similar nature but aimed at smaller businesses with fewer vehicles (SCAQMD).

Whilst these programs are a significant strategy that industries can adopt to reduce their emissions, it requires businesses to take it upon themselves to reach out and apply. Businesses need to be aware of these incentives and be interested in replacing or retrofitting their trucks in order for these programs to be significantly reducing emissions. Especially since the amount of freight activity is predicted to increase over the next years (SCAQMD, 2019), the programs will have to reach a significant number of businesses to mitigate the impact of this rise in truck-use. However, CARB and SCAQMD are currently testing out Automated License Plate Readers (ALPRs); cameras that can collect high-speed information regarding license plate numbers, model type, model years and other related data. Using this technology, CARB could identify older model heavy-duty trucks that frequent a certain road and actively reach out to the business associated with these vehicles and notify them that they could qualify for these incentives (SCAQMD, 2019). This proactive approach could reach more businesses than the current passive approach. However, AQMD staff are still developing a privacy policy that "protects the privacy of the registered truck owners" (SCAQMD, 2019).

Another regional approach aimed at reducing air pollution in Southern California is the state's Cap-and-Trade Program, which places a limit on greenhouse gas emissions from industries which gradually gets stricter over time. Industries can trade allowances among themselves that "let them emit only a certain amount, as supply and demand set the price" (Environmental Defense Fund). The trade of these allowances incentivizes companies to reduce their emissions as much as possible to save money, and the gradual lowering of the cap ensures that air pollution progressively decreases in the region. The system has shown to be somewhat effective in reducing overall greenhouse gas emissions, with emissions decreasing by 5.3% from 2013 to 2017. The Center for Climate and Energy Solution (C2ES) notes that "While it is difficult to establish causality between emissions reductions and any specific policy or market condition, at least some of this reduction can likely be attributed to California's cap-and-trade program, which covers about 85 percent of the state's emissions" (C2ES, 2020).

That being said, research has demonstrated that the Cap-and-Trade program "has not yielded improvements in environmental equity with respect to health damaging co-pollutant emissions", and the most polluting industries within the program are located in neighborhoods with "people of color and poor, less educated, and linguistically isolated residents" (Cushing et al., 2018). This demonstrates that whilst state-wide policies and incentives could help in reducing overall air pollution in the region, they do not necessarily improve - or could even worsen - the environmental burdens that disadvantaged communities face (Cushing et al.,2018). Therefore, community-based approaches to GHG reduction to complement state-wide policies are necessary to address the environmental injustice that impacts low-income communities of color.

Community-Based Approaches

Assembly Bill 617 (Garcia, 2016), which was passed in 2017, requires "new, community-focused actions that utilize statewide and regional strategies to reduce high cumulative exposure in California's disadvantaged communities" (CARB 2020). It takes a far more targeted approach to the issue by focusing efforts on communities that are disproportionately exposed to, and impacted by, air pollution by focusing on community-level emission reduction rather than only state level. In response to the AB 617 bill, both CARB and South Coast Air Quality Management District established programs that aim to improve monitoring and reduce emissions in Environmental Justice communities. One way in which the Cap-and-Trade program does address the environmental justice issue is through the state's revenue from the program, which is invested into the Greenhouse Gas Reduction Fund (GGRF), funding programs aimed at reducing greenhouse gas emissions within California, especially in disadvantaged communities. Since 2013, the GGRF has invested $11 billion dollars into GHG reduction programs, and in 2019 CARB appropriated $291 million dollars from the fund for community-focused air pollution programs and $492 for Low Carbon Transportation programs to reduce emissions from vehicles.

A significant part of this funding goes to the Community Air Protection Program (CAPP), a program established by CARB, which annually selects communities “within which community air monitoring systems and/or community emission reduction programs will be developed and implemented” (CARB 2020). The program works with stakeholders in disadvantaged communities to develop a comprehensive community plan that addresses air pollution specific to these neighborhoods. In 2018, South Coast AQMD - by legislative requirement - submitted a Community Recommendations for AB617 Implementation report to CARB to assist with the selection of communities for the CAPP program based predominantly off the CalEnviroScreen score. Pomona was grouped with Chino, Walnut and San Dimas and was given an overall prioritization of ‘Year 6+’ (SCAQMD, 2018), suggesting that the community is not a priority and should be reconsidered for the program in 2024.

The potential issue with grouping these cities together is that pollution exposure levels and population vulnerability characteristics vary greatly between these communities (CalEnviroScreen, 2018). As is shown on figure 19, Pomona has a far higher CalEnviro score than the other cities, especially higher than Walnut and San Dimas.

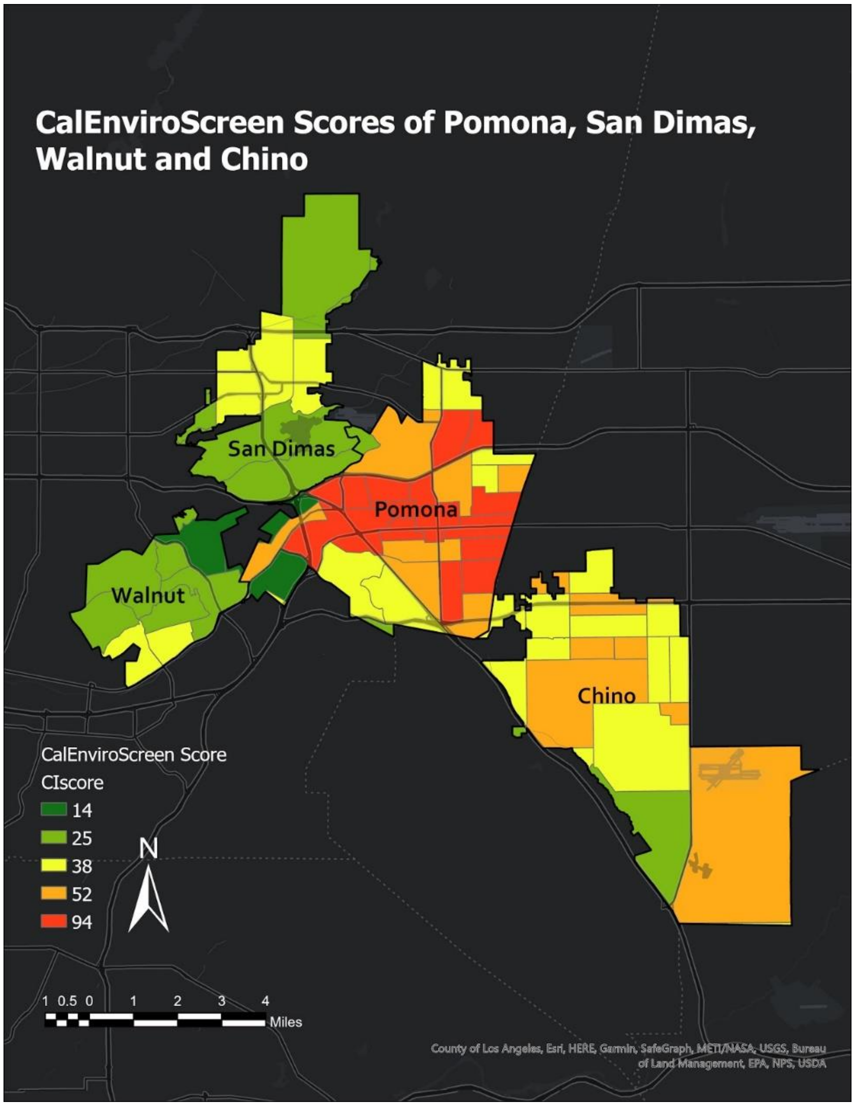

Figure.19 Map showing the CalEnviroScreen scores of Chino, Pomona, Walnut and San Dimas. (Source: CalEnviroScreen).

This means that Pomona residents are more exposed to, and more vulnerable to, multiple sources of pollution. Considering these cities one community undermines the severity of the issue of air pollution in low-income Latino communities in Pomona, and overlooks the fact that these neighborhoods could be considered a priority for SCAQMD and CARB programs. In order to better identify communities that would qualify as a priority for these programs, a more effective approach would include looking at the issue at a city or even a neighborhood scale.

An important part of any efficient community emission reduction plan is a comprehensive air quality monitoring system. The absence of local air quality monitoring could be contributing to the lack of urgency for air quality issues in Pomona. As is evident from my pilot study, there is an inadequate understanding of the neighborhood differences of $PM_{2.5}$ concentrations. The absence of even one monitor measuring $PM_{2.5}$ concentrations in the city implies that air quality is estimated through models using data collected from an Ontario monitor, which cannot accurately capture the disparities in exposure between small-scale areas. A local network of air quality monitors with a higher spatial resolution of $PM_{2.5}$ would be more effective at determining compliance with air quality standards, identifying specific sources of pollution in neighborhoods and giving a fuller understanding on how air pollution could be impacting the health of local residents (Jenkins, 2016).

Whilst CARB's air quality monitoring program is predominantly aimed at those communities already selected for the Community Air Protection Program, CARB offers Community Air Grants as part of the Greenhouse Gas Reduction Fund (GGRF) to community based-organizations for the implementation of AB617. The grants aim to fund community projects including "the development of methods to acquire new or better information regarding air quality and related health impacts, as well as measures to reduce air pollution in overburdened communities" (CARB, 2018). These grants offer up to $150,000 for participatory projects that support community involvement in city government decisions and up to $500,000 of technical support including, but not limited to, air monitoring, hiring technical experts and establishing community violation supporting systems (CARB, 2018).

Grassroot organizations like Clean and Green Pomona and United Voices of Pomona for Environmental Justice are very involved in the air pollution issue, particularly in the southeastern industrial area. They have successfully pushed for a reduction in truck routes, a moratorium on new recycling and waste facilities, and continue to advocate for great community involvement environmental issues that compromise these neighborhoods' public health. These grassroot organizations and their projects could qualify for the Community Air Grants that could provide funding for low-cost air quality monitoring technology that could contribute to a better understanding of poor air quality, it's sources and the impacts of it on residents. Particularly placing fence-line monitors adjacent to industries known for violating environmental regulations could keep these industries accountable for their emissions and assist regulators to enforce regulations (EPA, 2018).

Having air quality data to reinforce local residents' negative experiences with industry and pollutants would help grassroot organizations with advocacy and to push for support from federal agencies like CalEPA, CARB and SCAQMD, and also the local city government. As demonstrated with my pilot study, community members can contribute to this data collection by having low-cost monitors near their residences, which not only gives them information about their exposure to pollutants, but this also provides empirical evidence on the severity of the situation. Local air quality data that demonstrates unhealthy levels of pollution could be used as a powerful tool for raising awareness. For example, if these findings are taken to local media outlets, residents could be made aware of the air they are breathing which could lead to community action demanding better enforcement.

Grassroots organizations have already been successful in getting federal entities like CARB and CalEPA involved in air pollution within South Pomona. As mentioned in previous sections, in 2018, CalEPA's Environmental Justice Task Force published a Pomona Initiative Report after grassroot organizations "reached out to CalEPA to request support to address their concerns" (CalEPA, 2018), particularly regarding the southeastern industrial corridor. They carried out community workshops, conducted inspections of industries and heavy-duty diesel trucks and gave feedback on their findings. Three months after the inspection, "98% of those in violation", which included 70 industries and 68 heavy-duty diesel trucks "had made corrections and were deemed compliant" (CalEPA, 2018).

The involvement of CalEPA in the air pollution problem in Pomona clearly demonstrates that the environmental regulation laws are only as effective as the law enforcement. While these inspections were successful in keeping industries in check, there needs to be consistent enforcement, which includes comprehensive policy making that ensures periodic inspections of industry and freight traffic. Since CARB and SCAQMD are responsible for enforcing air quality regulations (CalEPA), grassroot organizations and community members should continue to reach out to these agencies regarding air quality concerns.

There are other ways to bring the issue to the greater attention of these agencies if residents feel like their complaints are not sufficiently taken into consideration. Larger, non-governmental organizations may have more power to influence federal agencies than smaller grassroot organizations as they generally have more resources and experiences in dealing with these entities. For example, Earthjustice, a "non-profit public interest environmental law organization" (Earthjustice), provides free legal representation for public interest groups, including many community-based organizations, in fighting for healthy living environments for community members across the nation. For over a decade they have been forcing the EPA and local air districts in the Central Valley through legal action to "put measures in place to come into compliance with the Clean Air Act" (Earthjustice). Examples of their work with communities through their Community Partnership Program is their collaboration with community groups within the Central Valley to "challenge the San Joaquin Valley Air Pollution Control District's decision to grant a number of unlawful loopholes that exempt the region's four petroleum refineries — concentrated in the Bakersfield area — from requirements to monitor their toxic emissions" (Earthjustice). They are now working on expanding their work to Los Angeles county.

I would encourage grassroots organizations in Pomona to continue to focus their efforts on outreach and raising public awareness within South Pomona regarding the environmental justice issue, as this will build a stronger base for advocacy. In addition, while pushing the city for policy changes has led to several policy changes that are important steps to cleaner air in South Pomona communities, the city is not the institution that is legally required to - nor has the resources to - enforce air quality regulations. Therefore, efforts driving change should instead be targeted at federal agencies, and grassroots should leverage the power and influence of larger organizations by coming directly into contact with them and using the vast amount of resources they have to offer.

While the city is not legally responsible for enforcing air quality standards, they are required to formulate policies and plans that address the needs of its residents. Under California state law, every city government has to develop a general plan, which "creates a vision for the foreseeable planning horizon — usually 10 to 20 years — and translates that vision into objectives, goals, policies and implementation programs for the community's physical development." (Institute for Local Government, 2015). General plans could be viewed as a blueprint for city planners with next steps for development, and therefore are an important indicator of a city's priorities and agenda. Although cities usually incorporate environmental sustainability goals in their general plans, some cities - like Pomona - develop green plans in addition to their general plans, which discuss “comprehensive environmental strategies that are intended to improve environmental quality and make rapid progress towards sustainability” (Environmental Encyclopedia).

Whereas Pomona’s General Plan - the most recent one having been published in 2014 - includes an environmental sustainability section, the Green Plan, developed in 2012, identifies more specific goals and policies. Regarding air pollution, for example, Goal 3.2 of the green plan is to “reduce GHG emissions related to Automobile and On-Road transportation systems”, and Policy 3.2.1 states that the city should “adopt a goal for a reduction of 5 percent from the baseline VMT per year of 2020” (City of Pomona, 2012). Within these policies, there are solid plans of action that can help city planners and other stakeholders to actively implement these policies into their work to ensure that these goals are met. Since many of these goals were intended to be met in 2020, I suggest the city revisits their green plan, identify goals that have and have not been met and update their green plan to address the current environmental issues that the city faces.

One important issue that neither the General Plan nor the Green Plan consider is environmental justice. As demonstrated from my research, low-income, Latino communities within the city are exposed to higher levels of pollution than richer, whiter, non-Latino communities. The only way these disparities can be addressed is if the city tackles these inequalities head-on by incorporating environmental justice into every aspect of their urban and environmental planning. SB1000, a bill passed in 2016, requires general plans to add an environmental justice element that “identifies disadvantaged communities” within the city and “identify objectives and policies to reduce the unique or compounded health risks in disadvantaged communities” (Leyva, 2016). This will require the city to not only include environmental justice integrated policies into the general plan, but also stand-alone policies that specifically target environmental injustice in the community.

Fortunately, there are several ways in which the city could effectively incorporate environmental justice into their planning. Firstly, tools like CalEnviroScreen are intended to be used by city governments and other relevant agencies to identify disadvantaged communities within their boundaries (CEJA, 2017). Additionally, grassroots organizations often have a great understanding of what specific neighborhoods are disproportionately impacted by environmental burdens, and may have members that live in these communities or are already actively working with community members in these areas. United Voices of Pomona for Environmental Justice offer gardening workshops in their Buena Vista community garden (Buena Vista Community Garden, 2020) and also organize toxic tours around the neighborhood to make residents aware of polluting industries (United Voices of Pomona for Environmental Justice, 2021), and are therefore consistently developing relationships with South Pomona community members. Additionally, United Voices of Pomona for Environmental Justice have members who are living in South East Pomona in the Industrial Zone who have a local understanding of the issues that are impacting them, their family and their neighbors.

If there is currently a lack of collaboration between the city government and South Pomona communities, grassroots organizations can act as a bridge between these two stakeholders. The city needs these connections as it will not be able to develop effective policies "to reduce the unique or compounded health risks in disadvantaged communities" without involving these communities in every step of the planning process. This means that residents should not just simply be informed on planning decisions that impact them, but historically marginalized communities should "lead and have ownership over the planning process and its outcome" (CEJA, 2017). Evidently, undemocratic planning practices in Pomona in the past have led to unequal burden sharing between neighborhoods, and the only way to remedy that is by redistributing power and giving environmental justice communities agency and autonomy over their urban environment. Collaborating with grassroots organizations to organize workshops where communities can express their concerns, whilst discussing how they want these issues addressed, will give the city government invaluable insight on next steps to take.

However, one significant factor that is currently preventing effective community participation is the language barrier that exists in the city. In Pomona, 53.39% of residents speak Spanish at home, whilst only 34.31% speak English at home (Esri, 2018). In some southern tracts of the city, the percent of Spanish spoken at home reaches as high as 84% (Esri, 2018). In addition, 2009 census data showed that 24.8% of residents spoke English "less than well" (Pomona Hope). Under Executive Order 12898 issued by President Clinton in 1994, federal agencies are directed to "promote nondiscrimination in federal programs that affect human health and the environment, as well as provide minority and low-income communities access to public information and public participation" (EPA). Despite Spanish being a dominant language in the city, the vast majority of resources on the city website are solely available in English. This excludes a large portion of the Latino population from being able to further participate in political matters as a significant part of public outreach happens exclusively through the website. For example, on March 22, 2021, the city published an application for residents to become part of the Independent Redistricting Commission that will "be responsible for reviewing and potentially realigning City Council electoral district boundaries based upon the 2020 Decennial Census" (City of Pomona, 2021). This is a critical moment in the city's political orientation, but a large part of its population will not be able to participate: the application to join in the commission is only available in English. This automatically prevents non-English speakers that may represent south Pomona Latino communities from speaking their voice on an important matter that could potentially have given these communities more political power. This problem also applies to environmental-related documents: the General Plan Environmental Impact Report (City of Pomona, 2013) and the Green Plan (City of Pomona, 2012) are currently only available in English. At the moment, one of the city's priorities for more inclusive planning practices should be translation of city planning documents and conducting workshops and public meetings in both Spanish and English.

Conclusion

My research on the topic of air pollution in the city of Pomona has demonstrated a gap in understanding of the way South Pomona neighborhoods are disproportionately breathing bad air from multiple sources due to an absence of a local air quality monitoring network. Spatial injustices, which have existed since the founding of the city, have created pockets of environmental injustice within the city in which predominantly low-income Latino communities are experiencing an excess of environmental burden. While studies continue to demonstrate the severe detrimental impacts of air pollution on human health, it is likely that particulate matter, among other pollutants, are contributing to the significantly higher prevalence of respiratory and cardiovascular issues that CalEnviroScreen has identified in these low-income Latino communities.

South Pomona is just one example of a larger group of communities along the Interstate 10 in Southern California and who have been historically excluded from planning practices and now suffer adverse health effects as a consequence. While the environmental injustice that exists within the city is a product of Pomona's history, communities across the region are fighting similar battles against the unequal share of environmental burdens they carry.

My research on air pollution in the city of Pomona thus serves to demonstrate the larger issue in Southern California: that federal, state and local agencies are failing to sufficiently address the environmental-justice issues that are rooted in deeper racial and social injustices that allow multiple sources of pollution to exist alongside low-income communities of color, putting their health at risk. What are needed are regional efforts that address the overall threats that climate change pose and combined with efforts to tackle the disproportionate impacts on disadvantaged communities. Although each agency has a differentiated responsibility in jurisdictional terms, they should coordinate and collaborate should be a joint effort to ensure healthy environments for these communities, and their ability to actively participate in decision making that directly impact them.

These communities through which I-10 runs are uniquely positioned to demand and coordinate a unified approach to directly address their common concerns. Mobilization of residents and the creation of partnerships between local grassroots organizations like United Voices of Pomona for Environmental Justice and Clean and Green Pomona, and national non-profits like Earth Justice can be a crucial strategy in addressing environmental issues. While the former has a strong understanding of local issues, the latter has resources and legal experience, and a collaboration of the two can prove to be a powerful way to make visible community issues at a regional level.

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