# Air Quality in Prince George's County During the COVID-19 Pandemic

Galina Koroleva, Michael Marinelli, Lily Oliver, James Via, Nefretari White
Under the supervision of Dr. Mark Carroll

Course #: ENSP400
The University of Maryland – College Park
Fall 2020

PALS - Partnership for Action Learning in Sustainability
An initiative of the National Center for Smart Growth

Gerrit Knaap, NCSG Executive Director
Kimberly Fisher, PALS Director

# Contents

## I. Sustainability Statement

The changes in human activity during the COVID-19 pandemic provided a unique opportunity to understand how reduced travel affects air quality in the Prince George's County area. When compared to years prior to the pandemic (2017-2019), ozone and NO2 emissions were significantly lower during the pandemic period. This suggests that reduced traffic and human movement contributed to decreases for these pollutants. Beyond damage to the natural environment, poor air quality negatively impacts human health and historically subjugated communities face disproportionate harm from poor air quality.

## II. Executive Summary

Communities most affected by air pollution, such as low-income communities and communities of color, are those also facing numerous systemic injustices. In Prince George's County there are high concentrations of economically disadvantaged neighborhoods identified by census tract characteristics such as Equity Emphasis Areas (EEAs). Low-income populations and people of color face health disparities due to lack of accessibility to health care, as well as adverse environmental factors such as pollution from traffic and local industrial facilities. Reducing exposure to poor air quality will require policies directed toward lessening the production of pollutants from these two sources.

The recent COVID-19 pandemic and resulting quarantines led to a reduction in traffic volume from the decreased travel and commercial activity, and therefore a reduction in car emissions. A behavior change occurred when quarantine began. The behavior shift caused decreased traffic volume because fewer people were driving and traveling out of state during the different phases. An opportunity arose to compare the human activity condition of 2020 to a baseline condition of 2017-2019. Ambient air quality could be examined, specifically that created or worsened by traffic emissions and industrial activity. Particulate matter, ground level ozone, and nitrogen dioxide (NO2) are pollutants emitted from exhaust in idling cars, created during combustion processes, and by chemical reactions between other pollutants and the sun, which may have impacted communities in Prince George's County, particularly communities of low-income people or people of color.

Daily air pollutant concentration averages from 2017-2019 were compared to values from 2020 over four different time periods related to the pandemic: pre-pandemic, pandemic, re-opening stage 1, and re-opening stage 2. Together, the four stages ran from February 5 to September 5. Pollutant averages were based on data obtained from five different air quality monitoring stations in Prince George's County and the District of Columbia. Spatial differences of ozone, NO2 and 2.5-micron particulate matter concentrations were examined by comparing concentration averages obtained from the monitoring station with the highest number of EEAs in a 12-mile radius of the station. GIS was used to visualize EEAs and traffic volumes in relation to air quality station locations and to determine the portions of Prince George's County toxic air emitting facilities located within a 12-mile radius of each monitoring station.

Between 2019 and 2020, the traffic volume in Maryland decreased at the start of the pandemic and maintained lower volume averages throughout the pandemic. Air pollutant concentration trendlines during the four study periods were similar to those in 2017-2019, though ozone and NO2 averages dropped and remained below 2017-2019 averages at the start of the 2020 pandemic. Additionally, the PM2.5 and PM10 averages for 2020 were consistently below the 2017-2019 averages at all phases. At the air quality monitoring station most relevant to Equity Emphasis Area air quality, 2020 NO2 and PM2.5 averages were greater than the same measurements at other stations with the opposite trend being the case for ozone. Overall, the spatial and temporal differences in air quality were generally small and air quality averages were never classified as unsafe. The air quality stations most relevant to Prince George's County Equity Emphasis Areas were not within the county.

Because the Equity Emphasis Areas are near areas of dense traffic and high pollutant areas, the health consequences for people who live in low-income neighborhoods and neighborhoods of color can be addressed through sustainability and environmental justice policies. These policies require cooperation among localities and varying government levels, and must consider impacts on EEA communities, as well as include the affected populations in decision-making.

## III. Introduction to the Problem

Prince George's County, within the Washington metropolitan area, is susceptible to poor air quality due to both the region's high traffic volume and the presence of numerous stationary sources of air pollution. Changes in air quality resulting from the COVID-19 pandemic may be important due to the ways poor air quality negatively impacts human health. Exposure to air pollution, such as ground level ozone (O3), nitrogen dioxide (NO2), and particulate matter (PM) can lead to health consequences including heart disease, stroke, lung cancer, respiratory infections, and pulmonary disease. Prolonged exposure can also lead to asthma and neurological damage, particularly for children raised in polluted environments (World Health Organization, 2018).

Ground-level ozone (O3) is created when fossil fuel combustion results in reactions between volatile organic compounds (VOCs) and nitrogen oxides. Its short-term impacts on human health include chest pain, coughing, and irritation; long-term impacts include decreased lung function, pulmonary disease, and exacerbation of existing respiratory issues. Nitrogen dioxide (NO2) is emitted by the transportation sector and concentrates around roads. It can cause and exacerbate asthma and bronchitis, as well as increase the risk of heart disease. Particulate matter smaller than 2.5 microns (PM2.5) is normally emitted by traffic; particulate matter less than 10 microns, or 0.01 mm (PM10) is generally associated with industrial and construction sites, as well as automobiles.

Both PM2.5 and PM10 can increase the risk of heart attacks, stroke, asthma, lung disease, cancer, and other heart ailments (Environmental Defense Fund, 2020).

In the summer months, prevailing wind patterns intermittently transport pollutants into Prince George's County from areas to the west (Washington DC and Montgomery County, Maryland), south (northern Virginia), and north (Baltimore). During this time of the year ozone production is typically at its highest and of greatest concern. Researchers have considered air quality station data more or less applicable in distances of 12 miles from where it is monitored (Bates, et a, 1988 ) however weather, more specifically wind, can influence the concentration of pollutants far from where they are produced or measured. The Air Quality System (AQS) stations collect data for both air pollutants and weather. Weather can cause significant variations in air quality among locations.

That spatial variability in measured air quality is important to consider when evaluating the health of Prince George's County's population, particularly among the County's economically disadvantaged populations and populations of color. These communities face challenges including systemic racism and classism, and economic struggles; air pollution adds the burden of disproportionate exposure to environmental health risks. The COVID-19 pandemic provides an opportunity to examine the County's air quality, how behavioral changes resulting from the pandemic affect air quality, and how air quality changes have affected communities of color. Incorporating this knowledge into policy actions is vital to addressing disparities between communities of color and other populations.

Equity Emphasis Areas are census blocks with a large number of low-income residents and residents of color and are identified by the Metropolitan Washington Council of Governments (MWCOG, 2018) to help address communities disproportionately affected by these governments' activities, policies, and programs. Residents of these areas struggle with poverty, poor transit service, and a lack of access to jobs and opportunities. MWCOG's Transportation and Planning Board plans to approach environmental justice by "analyzing current conditions and forecasting impacts of the long-range plan on traditionally-disadvantaged populations and by engaging potentially vulnerable populations in the planning process." (MWCOG, 2018).

Damaging health consequences are not experienced equally, with communities of color more likely to be disproportionately impacted (Gwynn & Thurston, 2001). To achieve environmental justice, it is necessary to remedy poor air quality by first finding and acknowledging the disparate effects. As defined by the Environmental Protection Agency (EPA), environmental justice is 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. This study uses Equity Emphasis Areas to understand and track correlations between regional socioeconomic inequity and spatial variation in air quality. With the analysis of Equity Emphasis Areas, it is possible to consider policies that could alleviate disparate health effects and achieve environmental justice.

Prince George's County has some organizational frameworks and policies for tackling poor air quality and its consequences. Permitting systems are in place and citizens can file complaints of indoor or outdoor air pollution (Prince George's County, 2020). The County's Environmental Justice Commission seeks to address potential inequitable health consequences that result from poor air quality (Prince George's County Environmental Justice Commission, n.d.). There is also a system of traffic management control strategies whereby citizens can request that specific streets are examined (Prince George's County Traffic Division, 2020). In an Environmental Justice Commission report, the intersection between traffic, air pollution, and public health was directly acknowledged as a potential issue to examine moving forward (Environmental Justice Commission, 2018).

On a national level, to protect public health, the Air Quality Index was established by the EPA to regulate major pollutants mentioned in the 1970 Clean Air Act. The index is divided into six categories of ambient air quality recorded at Air Quality Monitoring stations. Corresponding categories show the levels of health concern for the measured pollution concentration (Good, Moderate, Unhealthy for Sensitive Groups, Unhealthy, and Hazardous). For example, when an index value is over 100, the air quality is categorized as "Unhealthy for Sensitive Groups."

The Clean Air Act includes a permitting process for stationary sources that emit pollution above a certain level. These Title V Operating Permits have a minimum threshold of 100 tons per year for any air pollutant emitted from major sources. There are also more specific stipulations for area sources, minor sources, and non-major sources. There are state and federal incentive programs for reducing vehicle emissions and an EPA permit program, Title V permits, for tracking and limiting emissions from large stationary polluters.

To contextualize findings, deeper policy research is conducted to connect this information to the main findings.

## IV. Goals and Objectives

This study aims to identify significant emissions sources, discuss health implications, and provide policy considerations. Prince George's County can use this information to better contextualize COVID-19, guide general air quality policies, and enact policies specific to automobile usage.

<u>Objective 1</u>: Determine if there are differences in air quality during the first six months (March-September) of the pandemic compared to the same time period in past years, whether the differences are significant, and how they relate to changes in traffic volume.

<u>Objective 2</u>: Determine whether there are spatial differences (vicinity of industrial facilities/traffic volume) in air quality and whether they are significant.

<u>Objective 3</u>: Identify the significant sources of emissions and the extent of their impacts, including disproportionate effects on Equity Emphasis Areas.

<u>Objective 4</u>: Discuss the health implications of air quality changes on communities, determine to what extent racial and ethnic minorities are comparatively impacted, and research potential policies to address air quality and environmental justice issues.

Objective 5: Describe general health impacts and environmental justice issues, contextualize findings within that framework, research current County policies, compare them to existing policies in similar towns through case studies, and research potential policies that can be adopted.

## V. Materials and Methods

*Traffic*

Weekly percent change in traffic volumes between 2019 and 2020 in the County was obtained from the State Highway Administration. This data was measured by four traffic counters in Prince George's County located on major roads. The counters remained in place for 48 hours starting on a Monday or Tuesday. As explained later in this section, the relevant period spanned the weeks from January 1 to September 5 in both years.

*Air Quality Analysis*

Air quality measurements were obtained from the three air quality monitoring stations in the County: Beltsville, HU-Beltsville, and Prince George's Equestrian Center. The Beltsville and HU-Beltsville stations are located in the northern area of the county while the Equestrian Center is at the county's eastern-central edge. During the summer, prevailing winds generally carry air pollutants from the south and west into Prince George's County. In addition, most of the County's EEAs are located between Route I-95 and the County's western border with the District of Columbia (Figure 1). Because of this, two air quality monitoring stations in the District of Columbia, River Terrace and Takoma Recreation Center, immediately west of the border between the two jurisdictions, were added to the database to better represent air quality within the areas of interest in the County.

The availability of pollutant data varied among the stations. Daily maximum eight-hour ozone concentration (ppm) was retrieved from all five stations, whereas the daily maximum one-hour concentration (ppb) of NO2 could only be retrieved from the HU-Beltsville, Takoma Recreation Center, and River Terrace stations (Table 1). Similarly, the daily mean concentration (μg/m3 LC) of PM2.5 was available only from the HU-Beltsville and River Terrace stations while the availability of daily mean concentration (μg/m3 LC) of PM10 was limited to the HU-Beltsville station (Table 1). All air quality data was downloaded from the EPA Daily Data Download (U.S. Environmental Protection Agency, 2018a).

| Table 1. Pollutants measured at each station | | | | |
|---|---|---|---|---|
| Station Name | Ozone | NO2 | PM2.5 | PM10 |
| Beltsville | X | | | |
| HU-Beltsville | X | X* | X | X* |
| Prince George's Equestrian | X | | | |
| River Terrace | X | X* | X | |
| Takoma Rec. Center | X | X* | | |

* 2020 data only available through June 30

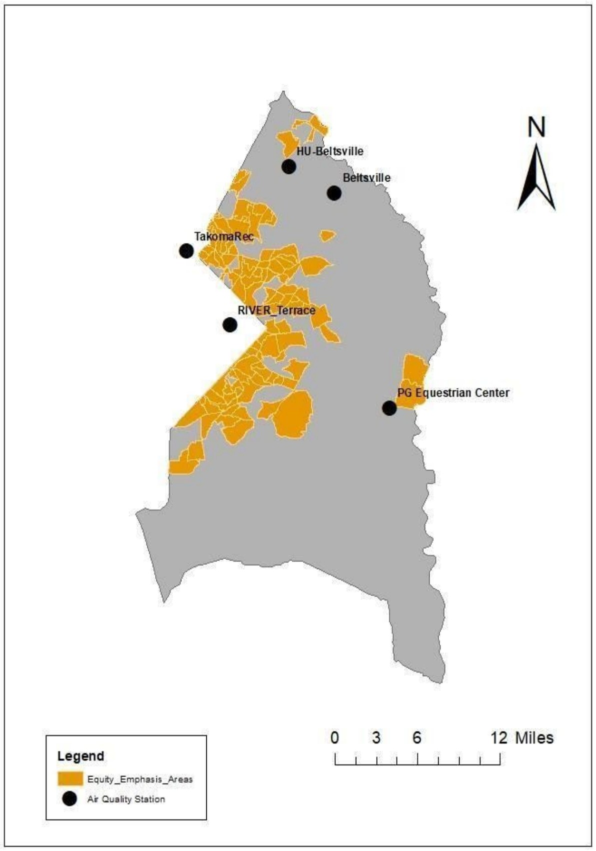



Figure 1: Locations of the five air quality monitoring stations in Prince George's County and DC. The EEAss in Prince George's County are shown in relation to the air quality monitoring station locations.

Temporal Analysis of Air Quality

The pandemic was split into three time periods based on the stages of lockdown. The first time period began on March 6, 2020 after Maryland Governor Larry Hogan declared a state-wide emergency (Hogan, 2020), and lasted 87 days. The second period began on June 1, 2020 and lasted 28 days when the County entered Phase 1 reopening by lifting the stay-at-home order (Alsobrooks, 2020-a). The third period began on June 29, 2020, when the County entered phase 2 of reopening (Alsobrooks, 2020-b), lasted 69 days, and ended on September 5. At that time, further limitations on the availability of air quality data arose at some of the stations (Figure 2). Air quality during this pandemic period was compared to a 30-day "pre-pandemic" period, which began February 5, 2020 and ended on March 5, 2020.

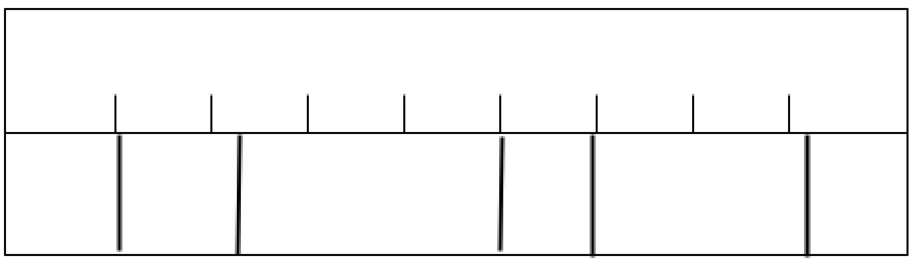


Figure 2: Timeline of periods analyzed. Periods 1, 2, and 3 were within the pandemic period, and "Pre-" refers to the 30-day control group of the "pre-pandemic" period.

Air quality in 2020 was compared to the 2017-2019 period by first calculating the daily average air concentration for the five air quality stations. The daily three-year averages were then paired with daily average air quality concentration for the five air quality stations in 2020. Some days were missing or inconsistent from year-to-year, such as leap days, and were therefore omitted. A paired t-test was applied to each period of the pandemic to generate a significance probability (P) for the period. Comparisons between years for each time period were considered significant when P was less than 0.05.

Spatial Analysis of Air Quality

A preliminary analysis of Equity Emphasis Areas showed that the River Terrace station contained the most Equity Emphasis Areas (87%). This station's values are therefore especially relevant for information about air quality within Equity Emphasis Areas. The ozone, NO2, PM2.5, and PM10 concentration averages for each period at all other stations were compared to the averages for each period at River Terrace. Only the 2020 period averages were used for these comparisons. A two tailed t-test was used to determine if the HU-Beltsville, Prince George's Equestrian Center, Takoma Recreation, and Beltsville stations had significantly different air pollutant concentrations than River Terrace for the four pandemic time intervals.

*Equity Emphasis Areas*

Traffic volume, industrial facility location, and Equity Emphasis Area census information were connected to individual air quality monitoring stations using ESRI ArcMap 10.8. Information was assigned to specific air quality stations based on a 12-mile buffer around the station that considered atmospheric transport and pollutant dispersion from vehicular and non-vehicular mixing of emissions (Bates et al., 1988).

The 12-mile buffers, or air quality impact zones, represented the measurement area and air quality monitoring station. This approach effectively treats the air quality station as the location of the point source pollution. This approach was necessary because air quality data from nearby large point sources emitters was not available but there was a need to account for their impacts on nearby communities.

Equity Emphasis Areas have a high concentration of low-income residents and people of color who were assigned index scores. Census tracts calculate total index scores by aggregating scores for low-income residents and people of color to reach an uncapped total. Scores greater than or equal to 4.00 are considered Equity Emphasis Areas (mcwog.org, 2020). The Equity Emphasis Areas were associated with an air quality monitoring station(s) to understand the air quality in those census tracts; for example, which pollutant concentrations were higher and how those concentrations changed (or didn't) over the pandemic period. Based on this information, we determined air quality in the area associated with the highest percentage of Equity Emphasis Areas.

The Total Index Scores were then divided into four tiers and ranked using the natural breaks (Jenks) classification method (Table 2). The tier with the highest values indicates the census tracts with the highest concentrations of low-income residents and communities of color.

Table 2. Equity Emphasis Area tiers are ranked Low to Very High concentrations of low-income minorities using the Natural Breaks classification method.

| Tier Based on Jenks Natural Breaks | Rank | EEA Index |
|---|---|---|
| 1 | Low | 4-4.9 |
| 2 | Moderate | 5-5.6 |
| 3 | High | 6.6-9.6 |
| 4 | Very High | 9.7-12 |

To identify emission sources that disproportionately affect Equity Emphasis Areas, the traffic data and industrial facilities within the air quality station impact zones are mapped as stationary sources. Traffic volume was considered using permanent count locations along interstates and highways in the County. The Maryland Department of Transportation State Highway Administration data is based on weekly averages for the years 2019 and 2020. A roads layer showed location and differences in traffic volume by line color and type.

The four permanent count locations in Prince George's County are:

1. I-95 - 1.02 miles south of MD 214
2. I-95 - .05 mile north of Good Luck Road
3. MD 4 - .54 mile north of Patuxent River Bridge
4. US 50 - .75 mile west of MD 202

*Review of Air Quality Policies*

To understand the legal context of air quality regulation, federal, state, and local government regulations were examined. EPA regulations were researched as implementations of federal law. State implementation of federal law and state laws regulating stationary and mobile sources of air pollution were also examined. Lastly, local policies were examined. Both stationary emissions and mobile emissions were researched.

The states are responsible for permitting and regulation of air pollution sources, including facilities that emit a large amount of air pollution under a Part 70 Permit (U.S. EPA, 2017-a, 2017-b). These operating permits include pollutant information and quantity. They also include the steps necessary to measure and reduce pollution (U.S. EPA, 2007). While the Clean Air Act sets a threshold, states can be more stringent in their permitting requirements. Maryland is not more stringent with major sources and opts to follow the EPA guidelines. Maryland does, however, have stricter permit thresholds for nitrogen oxides, volatile organic compounds (VOCs), and hazardous air pollutants (HAPs) outlined in Section 112(b) in the Clean Air Act (Maryland Department of the Environment, n.d.c.).

*Health and Environmental Justice*

Prince George's County tracks health data statistics including health indicators associated with air pollution exposure. Although these are not directly linked to specific locations of communities within Prince George's County, and there may be confounding factors, the data provides useful context for examining policies that might be pursued. Specific health indicators on the County's health indicator dashboard, PGC Healthzone, were sorted by conditions that can arise as a result of poor air quality, in this study, age-adjusted death rate due to lung cancer, lung and bronchus incidence rate, age-adjusted death rate due to cerebrovascular disease (stroke), high blood pressure prevalence, adults with asthma, age-adjusted death rate due to chronic lower respiratory diseases, and children with asthma. All indicators were sorted by race and ethnicity. Additionally, these indicators can be examined in relation to other metrics, including other Maryland counties, general US counties, and MD and US values (PGC HealthZone, 2020-a). The findings are presented through the website-generated graphics and contextualized alongside findings regarding changes in air quality.

*Approaches to Policy Recommendations*

For Prince George's county to implement transportation policies and strategies that will lessen air pollution, and subsequently lessen the burden on low-income communities, it's necessary to discuss the nature of transportation policies, their effectiveness, and where and how they've worked. The findings focus on case studies of successful air pollution policies in Maryland, around the country, and abroad. Whether these policies put an undue economic burden on low-income communities or whether they alleviate existing burdens is also to be examined. This analysis was approached with literature searches of peer-reviewed articles, government sources, reliable sites, and databases like GoogleScholar, EBSCO, and ScienceDirect.

## VI. Findings

*Traffic Volume*

In Prince George's County, traffic started decreasing mid-March and reached its lowest volume during April 7 - 13, 2020, at -48.2% difference from 2019 (Maryland Department of Transportation, State Highway Administration). Traffic decreased more than 25% between March 24 and June 6. This change in traffic volume aligns with Pandemic Period 1 (March 6 - 30). Figure 3 shows weekly changes at the permanent counter locations for the year 2019 to 2020.

According to State Highway Administration data, traffic volume reduced from 2019 values at the start of the pandemic and remained lower through Pandemic Periods 2 (June 1 - June 29) and 3 (June 30 - September 5). The four County locations, the permanent count locations, and the volumes are shown in Figure 4. Average volumes on the County's major roads are shown in Figure 5. All major roads where the counters are located are contained within the five air quality monitoring station impact zones, and the River Terrace zone contains all major roadways identified.

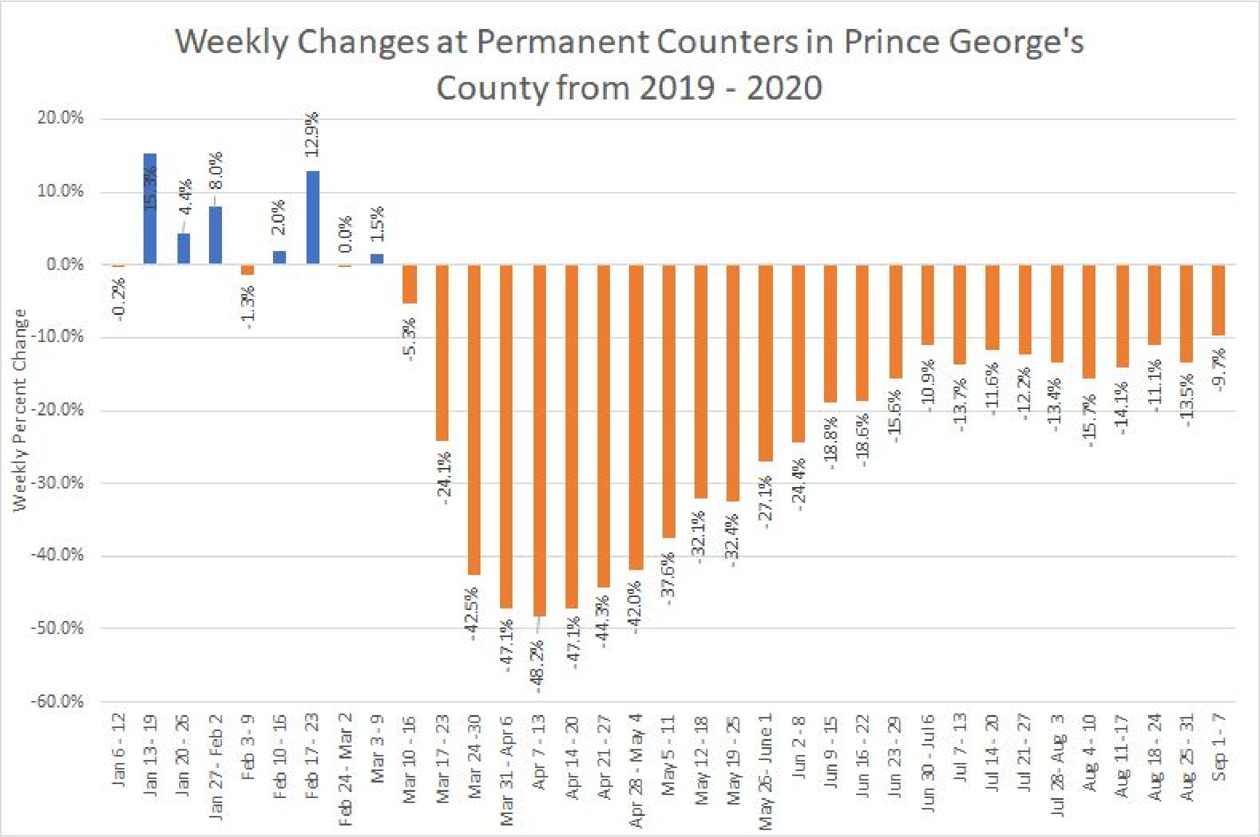



Figure 3. Weekly percent change of traffic volume between 2019 and 2020 for Prince George's County (MDOT SHA)

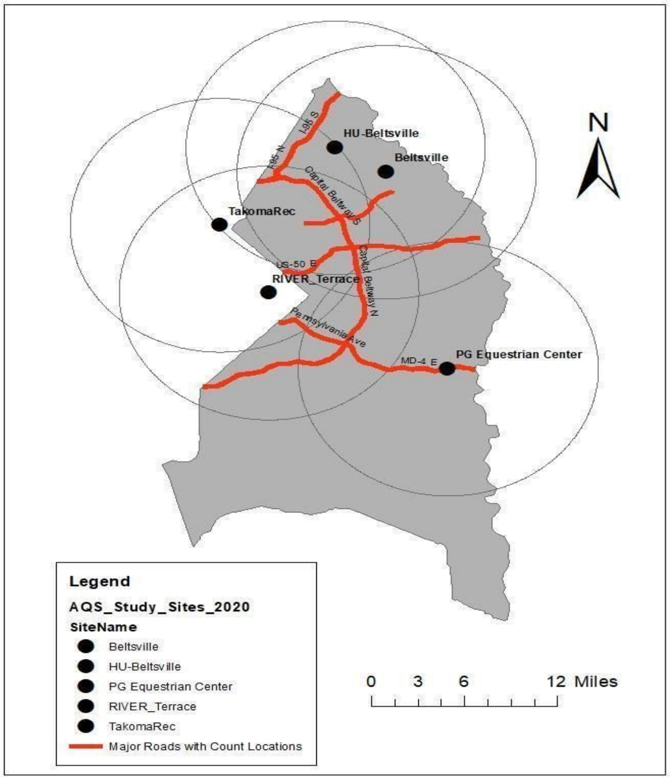



Figure 4. Air quality stations and major roads with count locations

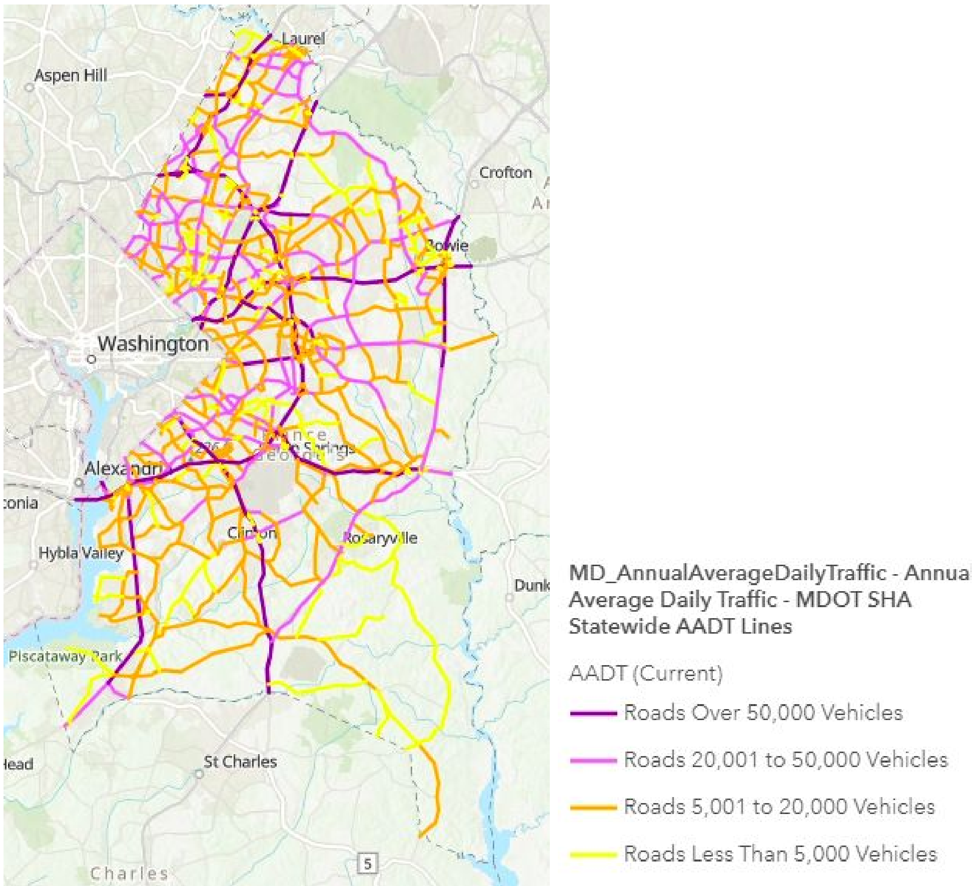



Figure 5. 2019 traffic volumes (Annual Average Daily Traffic) in Prince George's County (geodata.md.gov)

*Pollutant Concentration*

Figure 6 shows ozone concentration for each of the four time periods. When averaged over all the stations, ozone concentration increased as the year progressed in both pre-pandemic years and in 2020. The average ozone concentration over the three time periods in the early 2020 pandemic stages (March 6 - September 6) were lower than those recorded for the prior three years. Ozone concentration was slightly higher in 2020 than for the three years prior during the Pre-pandemic Period (February 5 - March 5). Three of the four differences were statistically significant with the differences being in general agreement with the traffic counts shown in Figure 3, although this figure only considers change in traffic volume between 2019 and 2020.

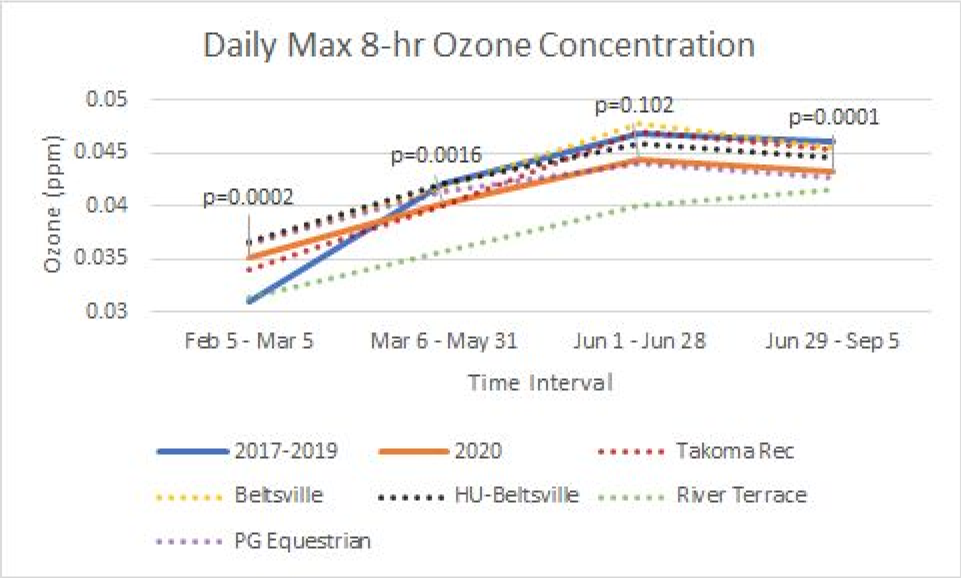



Figure 6. Daily average ozone concentration for time intervals corresponding to the "change date" in restrictions implemented during the 2020 COVID-19 pandemic. Values of $p<0.05$ indicate statistical significance

Data for NO2 was not available for all of pandemic period 3 (June 29 - September 5), so this period is not included in the analysis. In both 2017-2019 and 2020 NO2 averages decreased over the study periods (Figure 6). There is a significant and clear divergence of NO2 levels in 2020 from previous years. Nitrogen dioxide concentrations in the pre-pandemic period were higher on average, though not significantly so. However, the concentrations trend downward during 2020 beginning at Pandemic Period 1 (March 6 - May 31) and continues through Pandemic Period 2.

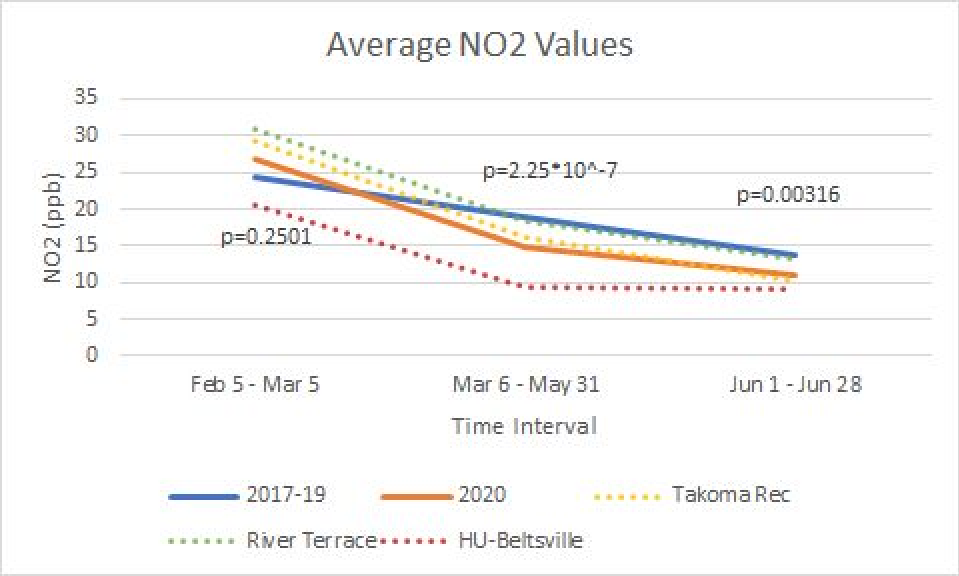



Figure 7. Daily average NO2 concentration for time intervals corresponding to the "change date" in restrictions implemented during the 2020 COVID-19 pandemic. Values of $p<0.05$ indicate statistical significance

The average concentrations of PM2.5 were lower during 2020 than in 2017-2019 averages for all of the periods examined. Generally, the values trend downward into Pandemic Period 1 and increase over the next two periods (Figure 8) for both 2017-2019 and 2020. The 2020 average is closest to the 2017-2019 average during Pandemic Period 3, when the difference is insignificant between the two.

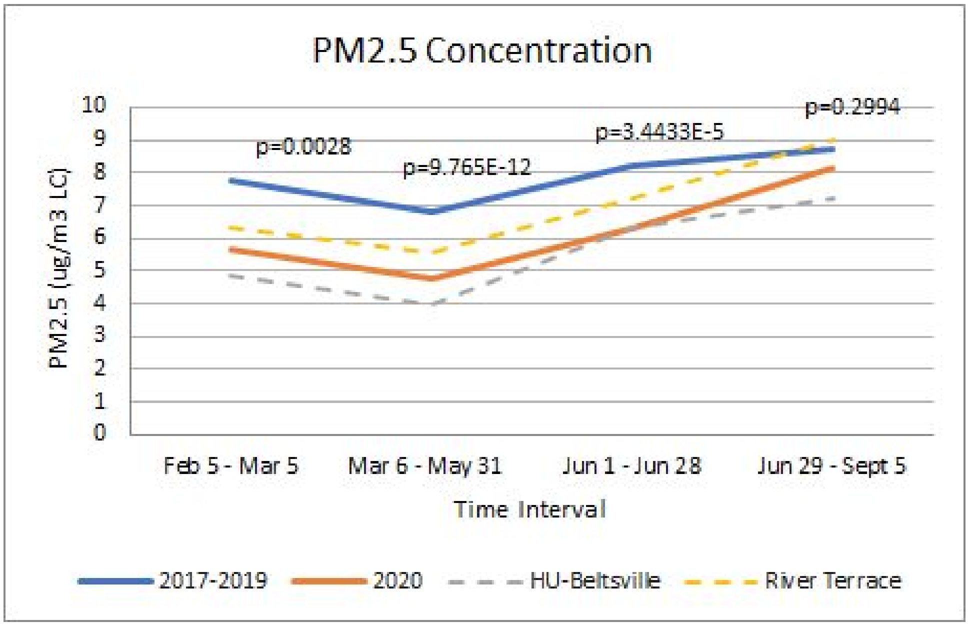



Figure 8. Daily mean PM2.5 concentration for time intervals corresponding to the "change date" in restrictions implemented during the 2020 COVID-19 pandemic. Values of $p<0.05$ indicate statistical significance

The PM10 concentrations for 2020 are all lower than the values for corresponding periods in the three years prior (Figure 9). The averages trend upward through all time periods for both 2017-2019 and 2020. The 2020 values approach the 2017-2019 values over the Pre-pandemic period to Pandemic Period 2, when the difference between the two values is lowest.

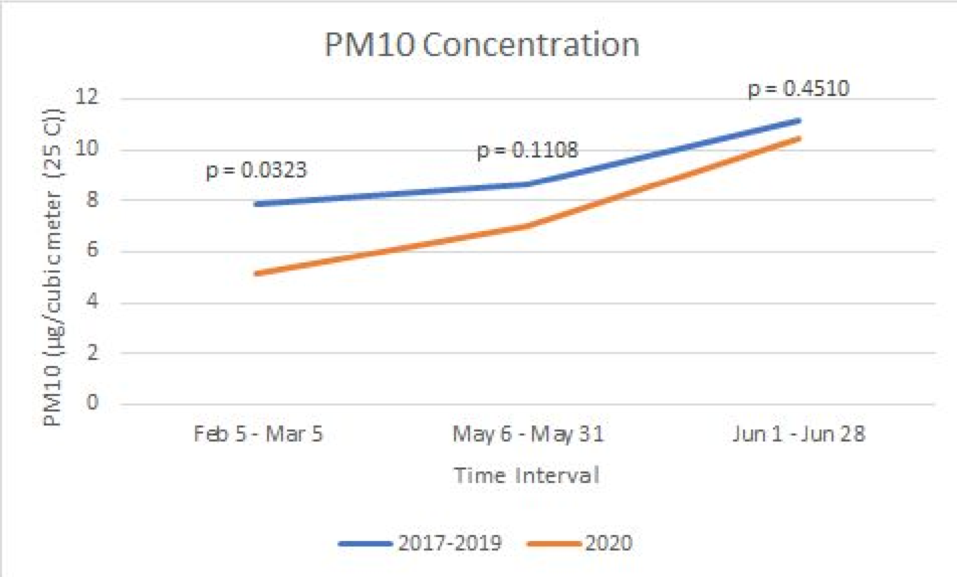



Figure 9. Daily mean PM10 concentration for time intervals corresponding to the “change date” in restrictions implemented during the 2020 COVID-19 pandemic. Values of $p<0.05$ indicate statistical significance

<u>Air Quality Differences Between Stations</u>

In both 2017-2019 and 2020, the Air Quality Index for measured air pollutants of all stations for all time periods is categorized as “Good” (Tables 4 - 8). However, there are differences in 2020 average pollutant concentration levels between stations when compared to River Terrace (Tables 3a, b). This station is especially relevant because it is located nearest to most of the County’s EEAs.

The average ozone concentration for each period at HU-Beltsville (Table 5) is significantly larger than measured at River Terrace. In the first two periods, Prince George’s Equestrian ozone concentrations are also larger than River Terrace, though the differences are not statistically significant in the two later study periods (Tables 3a, 3b, 6). The average ozone concentrations at Takoma Recreation Center and Beltsville are larger than at River Terrace for all time periods in 2020 (Tables 4, 7, 8).

Nitrogen dioxide averages at River Terrace are larger than those recorded at both HU-Beltsville and Takoma Recreation Center for the three periods (Tables 4, 5, 7). The difference between the River Terrace and Takoma Recreation Center NO2 averages during the pre-pandemic period was not statistically significant (Tables 3a, b).

The average concentrations of PM2.5 at HU-Beltsville are significantly lower than those at River Terrace for all study periods (Tables 3a,b and 5).

Analysis between stations is not applicable for PM10 because it was only measured at HU-Beltsville. The averages of PM10 are recorded in Table 5.

Table 3a. Probability that measured air pollutant is different than that measured at River Terrace air quality monitoring station for time periods correponding to changes in restrictions that were implemented during the COVID-19 pandemic in 2020. The significance value is $p < 0.50$. Note: PM10 is not included because it was only measured at one station, HU-Beltsville.

| Time of the year | Station Contrast with River Terrace # | Pollulant | | |
|---|---|---|---|---|
| | | Ozone | NO2 | PM 2.5 |
| | | Significant probability | | |
| 5 Feb to 5 Mar | HU-Beltsville | < 0.001 | < 0.001 | < 0.001 |
| | Prince George's Equestrian | < 0.001 | NA | NA |
| | Takoma Rec. Center | < 0.001 | 0.492 | NA |
| | Beltsville | < 0.001 | NA | NA |
| 6 Mar. to 31 May | HU-Beltsville | < 0.001 | < 0.001 | < 0.001 |
| | Prince George's Equestrian | < 0.001 | NA | NA |
| | Takoma Rec | < 0.001 | 0.014 | NA |
| | Beltsville | < 0.001 | NA | NA |
| 1 June to 28 June | HU-Beltsville | < 0.001 | < 0.001 | < 0.001 |
| | Prince George's Equestrian | 0.061 | NA | NA |
| | Takoma Rec. Center | < 0.001 | 0.016 | NA |
| | Beltsville | < 0.001 | NA | NA |
| 29 June to 5 Sept | HU-Beltsville | < 0.001 | NA | 0.01511 |
| | Prince George's Equestrian | 0.442 | NA | NA |
| | Takoma Rec. Center | 0.004 | NA | NA |
| | Beltsville | 0.001 | NA | NA |

# Contrast based on weather station data from 2020

Table 3b. Difference between River Terrace and other air quality monitoring station 2020 averages for each period (River Terrace period average - other station period average).

| Time of the year | Station | Pollutant | | |
|---|---|---|---|---|
| | | Ozone | NO2 | PM2.5 |
| | | Difference from River Terrace | | |
| 5 Feb to 5 Mar | HU-Beltsville | -0.006 | 10.469 | 1.437 |
| | Prince George's Equestrian | -0.005 | NA | NA |
| | Takoma Rec. Center | -0.003 | 1.527 | NA |
| | Beltsville | -0.005 | NA | NA |
| 6 Mar to 31 May | HU-Beltsville | -0.006 | 8.997 | 1.511 |
| | Prince George's Equestrian | -0.005 | NA | NA |
| | Takoma Rec. Center | -0.004 | 2.41 | NA |
| | Beltsville | -0.006 | NA | NA |
| 1 June to 28 June | HU-Beltsville | -0.006 | 4.037 | 0.889 |
| | Prince George's Equestrian | -0.004 | NA | NA |
| | Takoma Rec. Center | -0.007 | 3.226 | NA |
| | Beltsville | -0.008 | NA | NA |
| 29 June to 5 Sept | HU-Beltsville | -0.003 | NA | 1.764 |
| | Prince George's Equestrian | 0.001 | NA | NA |
| | Takoma Rec. Center | -0.003 | NA | NA |
| | Beltsville | -0.004 | NA | NA |

Table 4. Average concentration and Air Quality Index category for pollutants measured at the River Terrace air quality monitoring station between 2017 and 2019 and during the pandemic in 2020 for time periods corresponding to dates of the different restrictions that were implemented during the COVID-19 pandemic in 2020.

| Time of the year | Year | Pollutant | | | | | |
|---|---|---|---|---|---|---|---|
| | | Ozone | | NO2 | | PM 2.5 | |
| | | ppm | AQI index | ppb | AQI index | ug/m3 | AQI index |
| 5 Feb to 5 March | 2020 | 0.03133 | Good | 30.89 | Good | 6.31 | Good |
| | 2017-2019 | 0.01944 | Good | 27.79 | Good | 8.103 | Good |
| 6 Mar. to 31 May | 2020 | 0.03561 | Good | 18.45 | Good | 5.542 | Good |
| | 2017-2019 | 0.03122 | Good | 23.51 | Good | 7.688 | Good |
| 1 June to 28 June | 2020 | 0.04 | Good | 13.27 | Good | 7.248 | Good |
| | 2017-2019 | 0.03916 | Good | 17.71 | Good | 9.119 | Good |
| 29 June to 5 Sept | 2020 | 0.04151 | Good | N/A | N/A | 8.983 | Good |
| | 2017-2019 | 0.04074 | Good | N/A | N/A | 10.71 | Good |

Table 5. Average concentration and Air Quality Index category for pollutants measured at the HU-Beltsville air quality monitoring station between 2017 and 2019 and during the pandemic in 2020 for time periods corresponding to dates of the different restrictions that were implemented during the COVID-19 pandemic in 2020.

| Time of the year | Year | Pollutant | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ozone | | NO2 | | PM 2.5 | | PM 10 | |
| | | ppm | AQI index | ppb | AQI index | ug/m3 | AQI index | ug/m3 | AQI index |
| 5 Feb to 5 March | 2020 | 0.03663 | Good | 20.41 | Good | 4.873 | Good | 5.1 | Good |
| | 2017-2019 | 0.03491 | Good | 19.12 | Good | 7.031 | Good | 7.966 | Good |
| 6 Mar. to 31 May | 2020 | 0.04217 | Good | 9.46 | Good | 3.994 | Good | 7.036 | Good |
| | 2017-2019 | 0.04499 | Good | 13.73 | Good | 6.234 | Good | 8.612 | Good |
| 1 June to 28 June | 2020 | 0.04593 | Good | 9.14 | Good | 6.314 | Good | 10.22 | Good |
| | 2017-2019 | 0.04741 | Good | 10.4 | Good | 6.945 | Good | 10.39 | Good |
| 29 June to 5 Sept | 2020 | 0.04454 | Good | N/A | N/A | 7.219 | Good | N/A | N/A |
| | 2017-2019 | 0.0476 | Good | N/A | N/A | 6.998 | Good | N/A | N/A |

Table 6. Average concentration and Air Quality Index category for pollutants measured at the Prince George's Equestrian air quality monitoring station between 2017 and 2019 and during the pandemic in 2020 for time periods corresponding to dates of the different restrictions that were implemented during the COVID-19 pandemic in 2020.

| Time of the year | Year | Pollutant | |
|---|---|---|---|
| | | Ozone | |
| | | ppm | AQI index |
| 5 Feb to 5 March | 2020 | 0.03633 | Good |
| | 2017-2019 | 0.03946 | Good |
| 6 Mar. to 31 May | 2020 | 0.04135 | Good |
| | 2017-2019 | 0.04576 | Good |
| 1 June to 28 June | 2020 | 0.04393 | Good |
| | 2017-2019 | 0.04791 | Good |
| 29 June to 5 Sept | 2020 | 0.0427 | Good |
| | 2017-2019 | 0.04729 | Good |

Table 7. Average concentration and Air Quality Index category for pollutants measured at the Takoma Recreation Center air quality monitoring station between 2017 and 2019 and during the pandemic in 2020 for time periods corresponding to dates of the different restrictions that were implemented during the COVID-19 pandemic in 2020.

| Time of the year | Year | Pollutant | | | |
|---|---|---|---|---|---|
| | | Ozone | | NO2 | |
| | | ppm | AQI index | ppb | AQI index |
| 5 Feb to 5 March | 2020 | 0.03403 | Good | 29.38 | Good |
| | 2017-2019 | 0.03272 | Good | 25.01 | Good |
| 6 Mar. to 31 May | 2020 | 0.03994 | Good | 16.05 | Good |
| | 2017-2019 | 0.04199 | Good | 19.38 | Good |
| 1 June to 28 June | 2020 | 0.04704 | Good | 10.04 | Good |
| | 2017-2019 | 0.04948 | Good | 13.47 | Good |
| 29 June to 5 Sept | 2020 | 0.0453 | Good | N/A | N/A |
| | 2017-2019 | 0.497 | Good | N/A | N/A |

Table 8. Average concentration and Air Quality Index category for pollutants measured at the Beltsville air quality monitoring station between 2017 and 2019 and during the pandemic in 2020 for time periods corresponding to dates of the different restrictions that were implemented during the COVID-19 pandemic in 2020.

| Time of the year | Year | Pollutant | |
|---|---|---|---|
| | | Ozone | |
| | | ppm | AQI index |
| 5 Feb to 5 March | 2020 | 0.03636 | Good |
| | 2017-2019 | 0.03579 | Good |
| 6 Mar. to 31 May | 2020 | 0.04165 | Good |
| | 2017-2019 | 0.04617 | Good |
| 1 June to 28 June | 2020 | 0.0477 | Good |
| | 2017-2019 | 0.0496 | Good |
| 29 June to 5 Sept | 2020 | 0.04559 | Good |
| | 2017-2019 | 0.4944 | Good |

*Equity Emphasis Areas Results*

Equity Emphasis Areas are census tracts with a high concentration of low-income residents and residents of color. Census tracts have Total Index Scores calculated by aggregating scores for low-income people and people of color to reach an uncapped total. Total Index Scores greater than or equal to 4.00 are considered Equity Emphasis Areas (mcwog.org, 2020). Of all of the County's disadvantaged census tracts, 103 are within the air quality system impact zone. Table 9 shows the number of EEAs within each air quality station impact zone. High ranking index scores dominate in the 12-mile radius around each station.

The spatial analysis shows the most Equity Emphasis Areas in the River Terrace, Takoma Recreation Center, and HU-Beltsville AQS impact zones. The census tracts with the highest index scores fall into four zones. Most Equity Emphasis Areas with higher index scores are in northwest Prince George's County. Takoma Recreation Center, River Terrace, HU-Beltsville, and Beltsville overlap, indicating this area is impacted the most by low-income communities and communities of color and the air quality changes due to COVID-19. Figure 10 shows the overlap area most vulnerable to adverse changes in air quality. Figure 11 shows the ranking of Equity Emphasis Areas in the overlapping location. Figure 10 shows that 70% of the EEAs in the intersecting layer have total index scores 6.6 or greater.

When applying the buffer, we can see that River Terrace has the most Equity Emphasis Areas, with most of the highly disadvantaged census tracts in the northern part of the County. Figure 11 shows that four of the 12-mile buffers overlap with higher ranking Equity Emphasis Areas. This overlapping area is impacted when pollution is high in any of the Air Quality System impact zones (River Terrace, Takoma Recreation Center, HU-Beltsville, and Beltsville). If pollution is high in any of these four impact zones, it could affect a specific area. River Terrace has the largest influence over most Equity Emphasis Areas. The high-ranking Equity Emphasis Areas fall within the overlapping intersection as well as two Title V industrial facilities and I-95. Accordingly, air pollution changes recorded at any of these four stations may influence this highly impacted area.

The area with the highest ranking (most disadvantaged) EEAs also is within the area with the highest number of EEAs. This area, already highly disadvantaged, would also be the most impacted by poor air quality and by air quality changes. This area should be targeted because it contains the most EEAs.

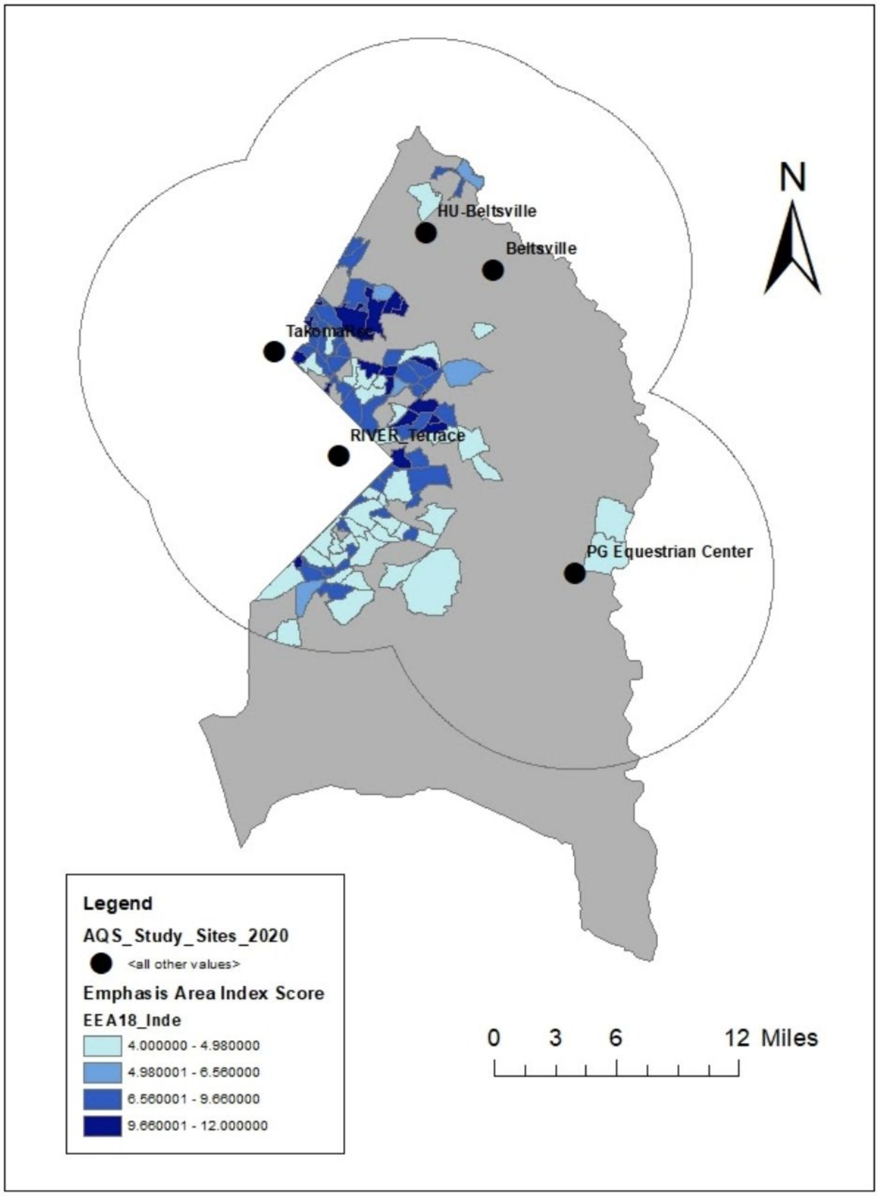



Figure 10. Equity Emphasis Areas within Air Quality System impact zones

Table 9. Air Quality station impact zones with different ranking Equity Emphasis Areas shown by numbers and percent.

| Air Quality Impact Area (12-miles) | EEA Census Tracts (103) (#) | EEA Rank/Tier Low | | Moderate | | High | | Very High | |
|---|---|---|---|---|---|---|---|---|---|
| Beltsville | 60 | 14 | 23.30% | 4 | 6.70% | 28 | 46.70% | 14 | 23.30% |
| HU-Beltsville | 58 | 11 | 19.00% | 4 | 6.90% | 27 | 46.60% | 16 | 27.60% |
| Prince George's Equestrian | 22 | 14 | 63.60% | 0 | 0.00% | 6 | 27.30% | 2 | 9.10% |
| Takoma Rec. | 74 | 22 | 29.70% | 3 | 4.10% | 32 | 43.20% | 17 | 23.00% |
| River Terrace | 96 | 37 | 38.50% | 4 | 4.20% | 37 | 38.50% | 18 | 18.80% |
| Intersect (not Prince George's Equestrian) | 51 | 10 | 18.50% | 4 | 5.60% | 24 | 44.40% | 14 | 25.90% |

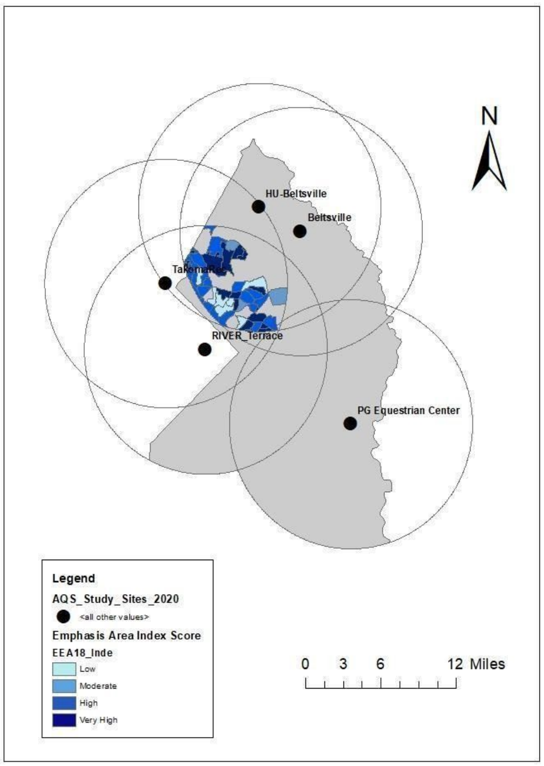



Figure 11. Of the County's 103 census tracts most impacted by differences in air quality, 51 are within the 12-mile radius of four stations

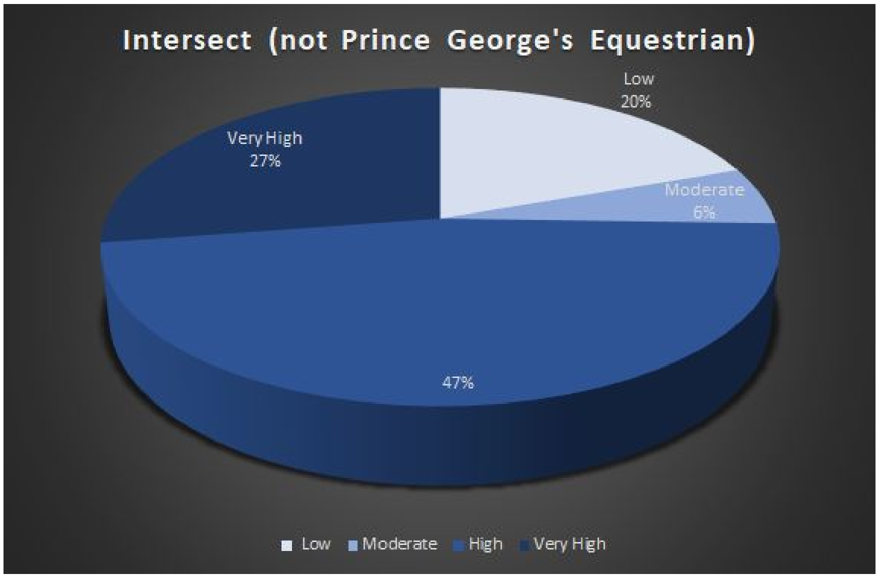



Figure 12. The proportion of each Equity Emphasis Area index area in the intersection area of River Terrace, HU-Beltsville, Takoma Park Recreation Center, and Beltsville. 74% of the census tracts in this intersection are classified as "High" or "Very High" concentrations of low-income people or people of color

*Stationary Emissions*

States are responsible for permitting and regulation of air pollution sources. The process includes facilities that emit a large amount of air pollution and receive a Part 70 Permit (U.S. Environmental Protection Agency, 2017-a). While the Clean Air Act sets a threshold, states can establish more stringent in permitting requirements. Maryland is not more stringent and follows EPA guidelines for major sources. Maryland does, however, have stricter permit thresholds for nitrogen oxides, volatile organic compounds (VOCs), and hazardous air pollutants (HAPs) outlined in Section 112(b) in the Clean Air Act (Maryland Department of the Environment, n.d.c.).

Not all Maryland counties are treated the same by these regulations. Air pollutants that exclude otherwise specified pollutants and HAPs apply to every county, but nitrogen oxides and VOCs have additional limits specified by county. In Prince George's County, all air pollutants that have a threshold of 100 tons per year from a stationary source must be regulated. Nitrogen oxides and VOCs both have a 25-ton-per-year threshold; stationary sources emitting 25 tons per year are required to go through the permitting process. Lastly, any stationary source emitting hazardous air pollutants as outlined in Section 112(b) of the Clean Air Act have a permit-requiring threshold of 10 tons per year per HAP (Maryland Department of the Environment, n.d.c.).

Maryland has issued more than 100 Part 70 Title V Permits (Maryland Department of the Environment, n.d.b.); nine are in Prince George's County, (Figure 13):

- Brown Station Road Landfill
- KMC Thermal Brandywine Power Facility

- NASA Goddard Space Flight Center
- NRG Energy, Inc. - Chalk Point Generating Station
- Prince George's Correctional Facility
- Sandy Hill Creative Disposal Project
- University of Maryland College Park (Steam Plant)
- US Army DEVCOM, Adelphi Laboratory Center
- WSSC Western Branch wastewater treatment plant

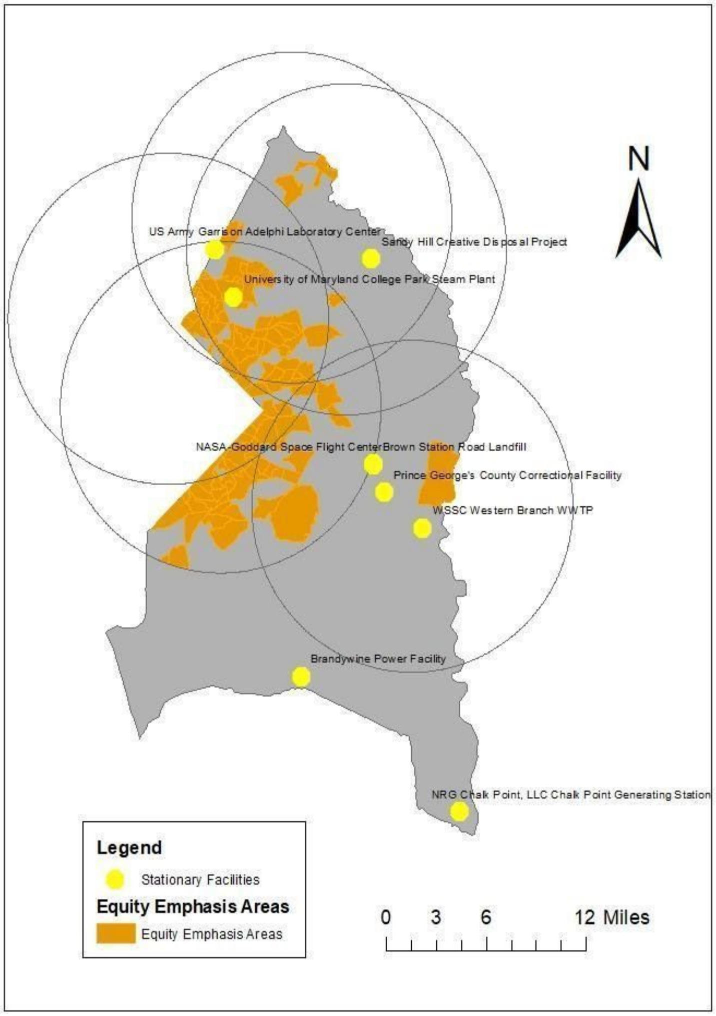


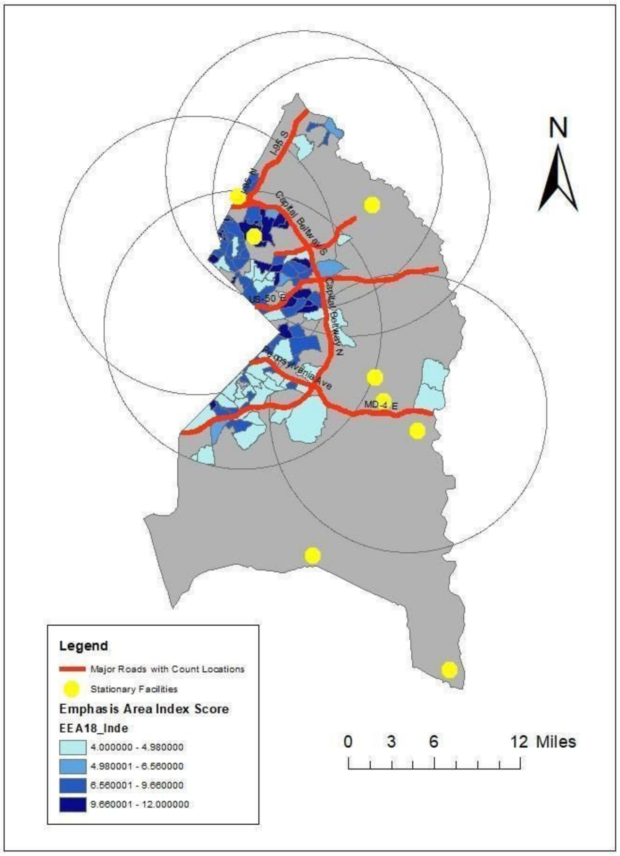

Figure 13. Prince George's County toxic air emitting facilities that report to EPA as Title V

Table 10

Equity Emphasis Areas Likely to be Exposed to Pollutants

| Air quality monitoring station | Percent of EEA within monitoring station exposure area | Percent of monitoring station toxic air emitting facilities |
|---|---|---|
| River Terrace | 87 | 22 |
| HU-Beltsville | 41 | 33 |
| Prince George's Equestrian | 29 | 44 |
| Takoma Recreation Center | 50 | 22 |
| Beltsville | 48 | 33 |

Facilities with Title V permits are spread throughout the County. River Terrace and Takoma Recreation Center have the lowest percentage of high emitting facilities within their buffers. I-95 extends through overlapping air quality system areas that also have a large number of Equity Emphasis Areas in tiers with high ranks. Tier 3 and 4 are classified as “high” or “very high” for low-income residents or people of color. Equity Emphasis Areas are correlated with areas of dense traffic and high pollutant areas (Figure 14).




Figures 14. Two toxic release facilities are in the area covered by all four stations. The buffer overlap also includes I-95 surrounding the highest Equity Emphasis Area scores

Prince George's County tracks and notifies citizens of both ground-level ozone and particulate matter levels through daily monitoring of Air Quality Index levels (Prince George's County, n.d.a). The County pays special attention to the criteria pollutants identified by the EPA—ozone, particulate matter, carbon monoxide, sulfur oxides, and lead—because of their impact on human and environmental health (Prince George's County, n.d.). The County also provides programs to reduce energy use (Prince George's County, n.d.b.).

*Health and Environmental Justice*

The health of low-income populations and populations of color suffers from poor air quality because they are often located near areas of dense traffic and stationary sources of air pollution (Pratt, 2015). These populations are also less likely to drive, instead using public transit; they are pollution's primary victims but not its main contributors (Pratt, 2015). In Prince George's County, Equity Emphasis Areas follow this pattern; they are near areas of high-volume traffic and high-pollutant areas and facilities.

The potential impacts of poor air quality on the County's vulnerable populations were found on its dashboard indicators. The dashboard does link health effects to specific areas but shows general trends for the County. Confounding variables make it difficult to directly link health effects to air quality concentrations. The indicators studied were cancer categories (age-adjusted death rate due to lung cancer, lung and bronchus incidence rate), heart disease and stroke categories (age-adjusted death rate due to cerebrovascular disease [stroke]), high blood pressure prevalence, and respiratory disease categories (adults with asthma, age-adjusted death rate due to chronic lower respiratory diseases, and children with asthma). The results were sorted by health indicator and by race and were compared to other Maryland counties (Figures 15 - 17).

Compared to most Maryland counties, these indicators are mostly within a green "safe" zone, though stroke, high blood pressure prevalence, and adults with asthma are within a yellow zone as "cause for concern" (PGC HealthZone, 2020-a). Because Prince George's County is populated primarily by non-white communities (around an 82% non-white population), is it vital that health impacts are not experienced disproportionately compared to other communities (PGC HealthZone, 2020-b).


Figure 15. Cancer categories: age-adjusted death rate due to lung cancer and lung and bronchus cancer incidence rate among Prince George's County residents, sorted by race (PGC Healthzone, 2020-a)

# Health / Heart Disease & Stroke

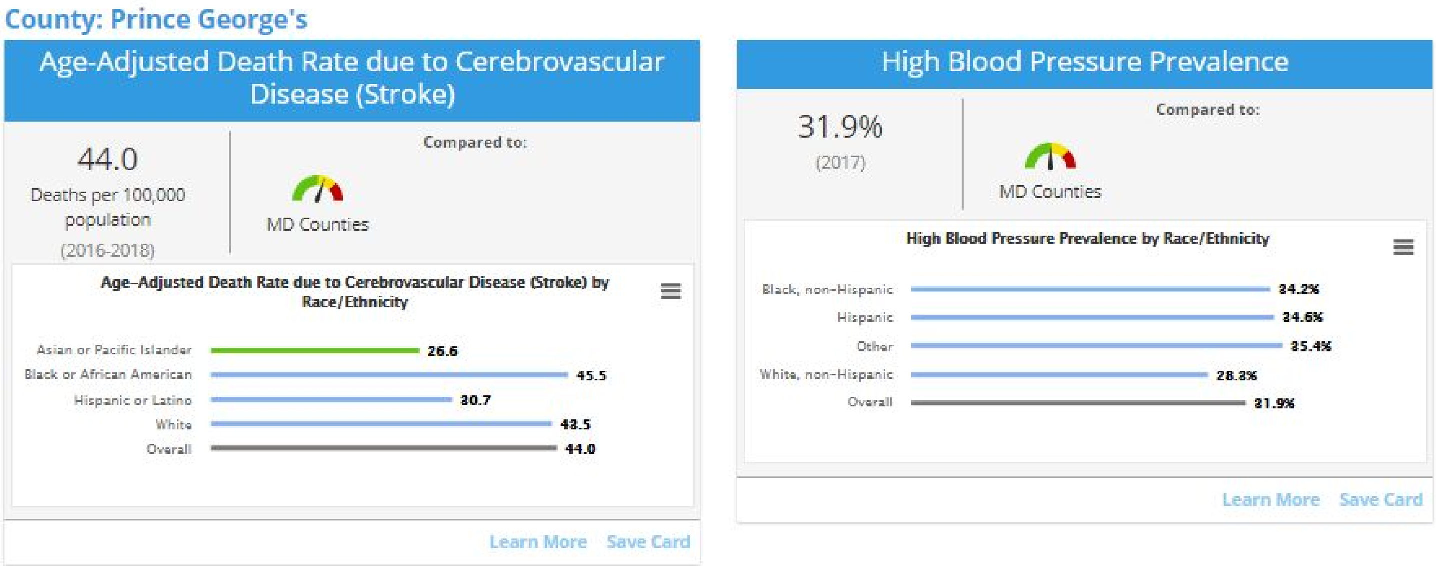



Figure 16. Heart disease and stroke: age-adjusted death rate due to stroke and high blood pressure incidence rate of Prince George's County residents, sorted by race (PGC Healthzone, 2020-a)

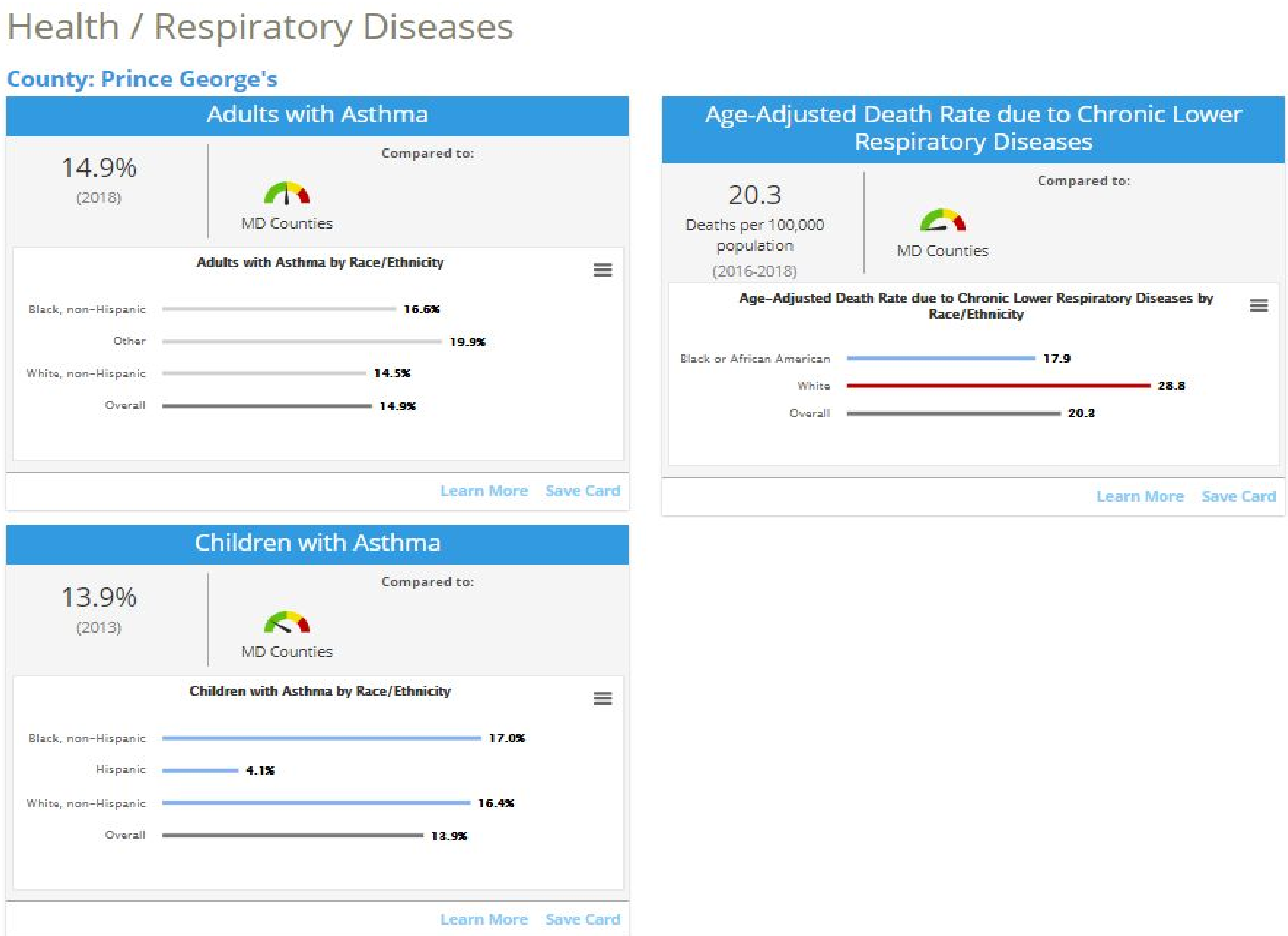



Figure 17. Respiratory disease: adults with asthma, children with asthma and the age-adjusted death rate due to chronic lower respiratory diseases of Prince George's County residents, sorted by race (PGC Healthzone, 2020-b)

*Mobile Emissions*

At the federal level, the EPA regulates vehicle emissions based on the vehicle type. These include but are not limited to aircraft, light-duty vehicles, heavy-duty vehicles, and locomotives. The EPA also regulates by fuel type: low sulfur gasoline or ultra-low sulfur gasoline. The EPA's main method of regulation is setting emission standards (U.S. EPA, 2017-c). There are standards for carbon monoxide, hydrocarbons, nitrogen oxides, particulate matter, and sulfur. The EPA also sets standards for fuel economy, per gallon mileage of gasoline vehicles, and for tailpipe greenhouse gas emissions. These standards preempt state and local standards (U.S. EPA, 2019a). This is the norm for federal environmental regulations, where the federal government sets a minimum standard and state and local governments can set higher standards, but not lower.

Additionally, as of June 2020, the EPA is increasing the stringency for CO2 emissions and fuel efficiency by 1.5% per year (U.S. EPA, 2020-b).

Maryland takes further steps beyond federal regulations. It has joined several other states to "incentivize transportation electrification and greenhouse gas (GHG) emissions reductions by supporting California's agreements with vehicle manufacturers who have voluntarily committed to producing cars that emit fewer GHG emissions thereby continuing to make annual reductions in GHGs from their vehicles" (Maryland Department of the Environment, 2020-a). Maryland's steps to further reduce emissions have been successful, with a volatile organic compound (VOC) emission rate that is 3.4 tons/day less than the federal rate and a nitrogen oxide emission rate that is 2.9 tons/day less than the federal rate. This is particularly valuable because both of these emissions are factors contributing to ground-level ozone, which is detrimental to human health. There are goals for furthering these standards by 2025 (Maryland Department of the Environment, 2020-a).

Maryland also offers incentives to reduce car emissions. For a cleaner commute, state public transportation includes light rail and buses. To reduce the number of cars on the road, the state promotes its public transportation, as well as biking, walking, and carpooling. Maryland also offers a tax credit to employers who provide employees with ways to shift away from single-occupancy car commutes (Maryland Department of the Environment, n.d.c). The current Maryland incentives to reduce emissions are discussed in the Policy Considerations section.

Prince George's County has a strong public transportation network with high ridership, due in part to the County's proximity to Washington, DC (Prince George's County, n.d.c.). The County also has a bicycle and pedestrian program with the goals of providing alternative modes of transportation and reducing congestion and emissions to improve air quality (Prince George's County, n.d.d.).

The County's RideSmart website provides information on alternative methods of transportation from carpooling to public transportation (Prince George's County Department of Public Works & Transportation, n.d.). The RideSmart program offers up to $260 per month to employees for use in SmarTrip public transportation in the Washington metropolitan area (Prince George's County Department of Public Works & Transportation, n.d.a.). Carpooling and vanpooling information offers ride-matching with other commuters (Prince George's County Department of Public Works & Transportation, n.d.b.) and financial incentives such as subsidies of up to $1,225 (Prince George's County Department of Public Works & Transportation, n.d.c.). This RideSmart site is further discussed in the Policy Considerations section.

*Transportation Policy and Case Studies*

Transportation policies to address air quality concerns are pertinent, as automobiles emit pollutants and contribute to ground-level ozone (Schuster, 2004). Policies to improve air quality can be sorted into two categories: hard and soft. Hard policies are characterized by actionable, physical changes, typically to infrastructure, land use, or roads (Santos et al., 2010). Examples include changes to public transport, urban planning, walking and cycling programs, and road construction, expansion, and monitoring (Santos et al., 2010). Soft policies focus on behavioral programs, education, and outreach, such as car-sharing clubs, eco-driving, and information campaigns (Santos et al., 2010). Soft policies are easier to implement but are typically regarded as less effective; they are often non-enforceable and focus on changing people's behavior (Santos et al., 2010). They are still useful for encouraging well-informed public participation in sustainability efforts.

Transportation policies addressing environmental issues can be judged effective if they result in significant changes in air quality. Due to limited data, there is limited evidence on the effectiveness of many transportation policies in improving air quality. Many policy options have been used, including road pricing, low emission zones, vehicle operating limitations, high occupancy vehicle lanes, lower speed limits, speed control devices, eco-driving, traffic signal timing, shared ride programs, employer programs, transit improvements, pedestrian/bike facilities, and outreach and marketing (Bigazzi and Rouleau, 2017). Road pricing and low emission zones show the most evidence of effect on air quality (Bigazzi & Rouleau, 2017). Additionally, used together, road pricing, lower speed limits, and eco-driving have been found to reduce pollutants between 1% and 4% (Bigazzi & Rouleau, 2017). Other promising policies include car-share, bike-share, and improved transit systems (Bigazzi & Rouleau, 2017).

Numerous world-wide case studies confirm the policies effective in changing air quality. In London, congestion charge zones (CCZ) and low-emission zones (LEZ) reduced traffic congestion, and subsequently reduced poor air quality. These policies may have also resulted in increased walking and cycling, though these were not formally studied (Giles et al., 2011).

In Milan, the effects of road pricing were studied over time, studying behavioral changes in response to the policy. It was found that the policy reduced both traffic and air pollution, with greater effects in areas with less public transit, which implies that road pricing and public transit options could potentially be substitutes, assuming an area already has high public transit usage (Gibson & Carnovale, 2015).

In the United States, California successfully formulated incentives to improve access to hybrid and electric vehicles for low- and moderate-income communities (Pastor et al., 2010). Purchase rebates were found to be more effective than loans, with purchase rates increasing as rebates increased: $2,500 rebates increased purchase rates by 20%, $5,000 rebates by 40%, and $9,500 rebates by 60-80% (Pastor et al., 2010). Increasing access to greener vehicles can have a positive effect by reducing the use of polluting automobiles, but it doesn't change the number of cars on the road. California and Maryland have also both implemented policies that encourage green infrastructure and equity by prioritizing the "allocation of Low-Income Housing Tax Credits to transit-accessible areas" (Sanchez et al., 2003).

Effective transportation policies must consider equity issues. Not only do communities of color face the higher burden of air pollution, but they may also be negatively impacted by poorly formulated transportation policies. When considering transit fees and organization, it is important to remember that "people of color have higher poverty rates, [and] they also have higher rates of using public transportation to travel to work" (Sanchez et al., 2003). Communities of color can also be underfunded: in Maryland, the Baltimore County received the lowest federal highway funding per capita, with rural and suburban areas given preference (Sanchez et al., 2003).

The best transportation policies research and prioritize the needs of low-income people and communities of color, through "data collection about minority pedestrian activity" and "programs that reduce air pollution from diesel and other vehicular exhaust" (Sanchez et al., 2003). Policies must have public participation from low-income populations and populations of color, with increased access to decision-making and planning (Sanchez et al., 2003). Outreach and information programs in particular seem pertinent to removing barriers.

When determining the best policies for Prince George's County, it is important to consider effectiveness, equity, applicability and effectiveness of hard and soft policies, and what the County government can accomplish. Turning to what other Maryland counties and cities have done can provide insight into potential steps. The City of Rockville's comprehensive plan acknowledges the connection between air quality and transportation policies. Policies to improve air quality included "promoting employee telecommuting, increasing the subsidies for the use of public or alternative forms of transportation, supporting 'bike to work' programs and facilities, and increasing the number of city fleet vehicles that utilize an alternative fuel source" (City of Rockville, 2002).

The City of Havre de Grace has purchased electric vehicles for its fleet and installed electric vehicle charging stations (City of Havre de Grace, 2017).

Montgomery County has implemented a Bicycle Master Plan that estimates a reduction in automobile emissions of "approximately 1.5 to 2 percent per year by 2040" (Anspacher, 2020).

Towns and cities in Prince George's County have policies that could be implemented county-wide. Hyattsville has studied areas where walking and biking needs could be improved (City of Hyattsville, 2018). It has also expanded their police department's e-vehicle fleet, and included anti-idling devices (City of Hyattsville, 2020). The city also participates in the Capital Bikeshare program, managed by Prince George's County, and it maintains bicycle lanes, paths, and signage (City of Hyattsville, 2019).

Based on these case studies and guiding ideas, policy recommendations are discussed and recommended.

## VII. Discussion

*Summary of Data Results*

The 2017-2019 ozone and NO2 averages during the Pandemic Periods were significantly higher than the 2020 averages. Reductions in traffic volume were also recorded at this time, suggesting that reduced traffic lead to the lower ozone and NO2 averages. In contrast, the 2020 PM10 and PM2.5 averages do not differ from the 2017-2019 values. Therefore, there isn't necessarily an impact on PM2.5 and PM10 with respect to the Pandemic Period.

During the 2020 time periods, NO2 and PM2.5 were higher in River Terrace, the station associated with the most EEAs, than in the AQS impact zone of any other recording station.

However, the ozone averages at River Terrace were lower than those in all other stations. So, it appears that NO2 and PM2.5 reductions would be especially applicable for improving air quality in the greatest number of EEAs. Of these two pollutants, only NO2 was significantly lowered by the impacts of the pandemic.

PM10 was only recorded at one station, HU-Beltsville. Due to the relatively small data set, significance and applicability of the results is not as great as ozone or NO2. Without comparison to other stations, the data is susceptible to variability of locations, making it less reliable. This concern also applies to PM2.5, which was recorded at two stations and, to a somewhat lesser degree, NO2, which was recorded at three stations.

The highest nitrogen dioxide concentrations were recorded in River Terrace during the first period of the pandemic, implying that this area has significant NO2 emissions from the density of industry and traffic. The pollutant concentration for ozone decreased at all of the stations but was highest in impact zones with fewer Equity Emphasis Areas. The high ozone levels remained outside high traffic volume areas. Pollution from high volume areas may be displaced by wind to zones with fewer pollution sources.

During the 2020 pandemic periods, the average concentrations of NO2 and PM2.5 remained higher at River Terrace than at the other stations. Since this zone contained the most Equity Emphasis Areas, it suggests that these areas are especially disproportionately affected by NO2 and PM2.5.

The 12-mile radius was used to account for dispersion of pollution. The influence of ambient air quality at the stations impacted Washington DC and Montgomery, Howard, Anne Arundel and Calvert Counties. Although the AQS station impact zone's 12-mile radius was large it didn’t cover all of the County. The Takoma Recreation Center and River Terrace monitors are not located in Prince Georges but contain the most EEAs.

The most Equity Emphasis Areas are located in the River Terrace air quality impact area—37 High and 14 Very High areas, the greatest proportion contained by the AQS impact zones. The Equity Emphasis Areas with High index scores are mainly located in the northern portion of Prince George’s County. The overlapping area is disproportionately burdened with heavy traffic, neighboring city pollution, and densely packed industry.

*Policy Considerations*

It’s important to focus on transportation emissions because they are the fastest growing source of CO2 in the US; car emissions account for one-third of Maryland’s CO2 emissions (Maryland Department of the Environment, 2020-a).

Maryland’s Clean Commute program incentivizes consumers to carpool, use public transportation, bike, or walk to replace single-occupant vehicle use. The state also provides a Clean Commute tax credit for Maryland employers that provide alternative methods of transportation to employees (Maryland Department of the Environment, n.d.a.). Further incentives for employees could be useful. The Clean Commute tax credit, while a valuable policy, benefits employers; it could be expanded to benefit employees opting to take alternative transportation.

Tax credits are offered for purchasing electric or hybrid vehicles. Consumers can receive a federal tax credit up to $7,500 and in Maryland, they can receive a credit up to $3,000. Additionally, both the federal and state governments offer rebates for new electric vehicle plug-in stations (Maryland Department of the Environment, 2020-b). While these rebates and tax credits can be valuable for consumers, they are market-based solutions predicated on purchasing new items rather than reducing use. Without changing the market-based solutions, emissions reductions could be further encouraged by focusing on incentivizing alternative transportation.

The Clean Commute tax credit for employers is one example. This program could be expanded and tax credits like it could be established to help reduce the number of cars on the road through public transportation, teleworking, walking, biking, and carpooling. Policies that focus on switching from one car type to another (standard to hybrid or electric) or expanding the use of a car type (increasing the number of hybrid or electric) don't reduce the number of cars on the road. And, because lower-income people and people of color are more likely to use public transportation, incentives for purchasing electric or hybrid vehicles would be less effective than more transit options or reduced transit fares.

The RideSmart website, created by the Prince George's County Department of Public Works & Transportation, offers helpful information in one, easily accessible place. Its incentives focus on reducing car traffic through carpooling, vanpooling, and public transportation. The vanpool incentive is, according to the site, "the most generous vanpool subsidy in the Metropolitan Washington area" (Prince George's County Department of Public Works & Transportation, n.d.c.). The carpooling incentives could be increased to meet the high standard set by vanpooling. The incentives for public transportation could be increased, such as increasing the tax-free Smart Benefits loaded monthly onto the SmarTrip card (Prince George's County Department of Public Works & Transportation, n.d.a.).

Policy changes must also be multi-dimensional so they don't create new air pollution problems. For example, gains in reduced tailpipe emissions have been offset by a general trend of increased driving distances (Harrington, 1994). Multi-dimensional policies can be difficult for a single county to implement but should still be considered. The most effective policies should scale beyond Prince George's County.

The need to scale up and policy cooperation between governmental levels requires multiple levels of coordination. This is evidenced in the shared impacts of air pollution. Wind patterns spread air pollution in the District of Columbia into Prince George's County. Likewise, traffic crosses boundaries; Prince George's County traffic is generated by drivers in the county and in neighboring counties who commute through Prince George's County. These types of issues require inter-jurisdictional cooperation.

Policies are most effective when they incorporate equity considerations. Hard policies such as improved transit options, e-vehicles, walkability, bicycle plans, and low-emissions zones are consistently effective, and have the added benefit of being more accessible to communities of color, whose residents are more likely to use public transit. Policies such as road pricing and other fee options ought to be carefully considered, to avoid burdening low-income communities. Economic policies such as rebates and incentives could be a more equitable way of pursuing air quality. Soft policies such as education and outreach may be less effective, but they can help increase equitable access to information and infrastructure planning. Conducting studies on potential areas to improve infrastructure for vulnerable populations would be another way to involve communities of color in policy decisions.

## Conclusions

Compared to 2017-2019, the ozone and NO2 averages are significantly lower during the 2020 pandemic. This is especially notable as the pre-pandemic averages for 2020 were significantly higher than the 2017-2019 pre-pandemic averages. This suggests that the decreased traffic volume caused by the pandemic may have contributed to improved air quality for ozone and NO2.

Mean concentrations PM2.5 and PM10 were significantly lower in 2020 when compared to 2017-2019, during all four evaluation periods, suggesting that particulate matter pollution below 10 micrometers was not closely tied to changes in traffic volume.

Nitrogen dioxide and ozone decreased during the pandemic period. During the 2020 pandemic, the area with the most Equity Emphasis Areas had higher NO2 and PM2.5 than other zones.

Key Points

- Ozone and NO2 averages were significantly lower during the 2020 pandemic periods, suggesting that reduced activity during the pandemic may have contributed to better air quality.
- River Terrace, which contains the most Equity Emphasis Areas, had higher NO2 and PM2.5 than recorded at the other air quality monitoring stations.
- Temporal air quality differences were generally non-impactful to health, as the Air Quality Index remained “Good” at all locations during all periods.
- The most and highest-ranked disadvantaged census tracts are in four of the five Air Quality Station impact zones.
- Stations and areas most relevant to Prince George’s County Equity Emphasis Areas are located outside the County.
- Effective sustainability and environmental justice policies require cooperation between jurisdictions and levels of government.
- Policies must consider the potential negative impacts on communities of color and incorporate impacted populations into the decision-making process.

The change in ambient air quality can be attributed to phenomena such as traffic, industry, and surrounding extraneous variables, such as weather. Although all the criteria pollutants regulated by the EPA have major health implications, it is essential to identify what can most effectively influence poor air quality in Prince George's County. It is important to acknowledge that on average, all stations maintained "Good" AQI ratings in all years and time periods.

Using guiding case studies and established transportation policies, health effects that arise from poor air quality can be mitigated in affected communities provided that the policies chosen are effective, cooperative, and targeted to the community's needs.

*Areas of Further Study*

This study may be furthered by using weather modelling in the spatial analysis of pollutants to construct more accurate estimations of pollutant distribution given the locations of monitoring sites. For example, higher temperatures might have contributed to the higher ozone concentrations.

Additionally, pollutant type and emission level data for industrial facilities may further inform air quality trends and consequential impacts on Equity Emphasis Areas. Overall, additional air quality monitoring stations more equally distributed throughout the County would allow a more complete analysis of air quality trends, the identification of effects of different emissions sources, and quantification of the impact on communities throughout Prince George's County.

Additional data about air pollutant sources and emission quantities during the study periods would provide insights about the observed air quality changes over the pandemic periods and between stations. Though beyond the scope of this study, further contextual knowledge, such as weather and industrial facility emissions, would provide supporting evidence of air quality changes over the pandemic period. Examination of local extenuating factors should be completed in future studies to explain the causes of the pandemic's impacts on air quality.

Another area of further study is the exact health effects that air quality changes may have on Prince George's County residents. Health indicators can potentially be another mark of successful implementation of transportation policies and can provide valuable contextualization to the reasoning behind pursuing such policies.

## Works Cited

Alsobrooks, A. (2020-a). *COUNTY EXECUTIVE ALSOBROOKS ANNOUNCES MODIFIED PHASE ONE REOPENING FOR PRINCE GEORGE'S COUNTY ON JUNE* 1 [Press Release]. Office of the Prince George's County Executive. https://www.princegeorgescountymd.gov/ArchiveCenter/ViewFile/Item/3222

Alsobrooks, A. (2020-b). COUNTY EXECUTIVE ALSOBROOKS ANNOUNCES FULL PHASE TWO REOPENING FOR PRINCE GEORGE'S COUNTY ON JUNE 29 [Press Release]. Office of the Prince George's County Executive. https://www.princegeorgescountymd.gov/ArchiveCenter/ViewFile/Item/3239

Anspacher, D. (2020). *Bicycle Master Plan*. Montgomery Planning. Retrieved November 18, 2020, from https://montgomeryplanning.org/planning/transportation/bicycle-planning/bicycle-master-plan/

Bigazzi, A. Y., & Rouleau, M. (2017). Can traffic management strategies improve urban air quality? A review of the evidence. *Journal of Transport & Health*, *7*, 111–124. https://doi.org/10.1016/j.jth.2017.08.001

Brandt, E. B., Beck, A. F., & Mersha, T. B. (2020). Air pollution, racial disparities, and COVID-19 mortality. *The Journal of allergy and clinical immunology*, *146*(1), 61–63. https://doi.org/10.1016/j.jaci.2020.04.035

City of Havre de Grace. (2017). City of Havre de Grace installs Electric Vehicle (EV) Charging Station.Havre de Grace Official City Website, Retrieved November 18, 2020, from https://havredegracemd.gov/city-of-havre-de-grace-installs-electric-vehicle-ev-charging-station/

City of Hyattsville. (2020). The Hyattsville City Police Department is Getting Cleaner & Greener!: Hyattsville, MD - Official Website. Retrieved November 18, 2020, from https://www.hyattsville.org/733/Electric-Police-Vehicles

City of Hyattsville. (2018). *Hyattsville Transportation Study.* Toole Design. Retrieved November 18, 2020, from http://www.hyattsville.org/722/Transportation-Study

City of Hyattsville. (2019).Bicycle and Pedestrian Improvements: Hyattsville, MD - Official Website. Retrieved November 18, 2020, from https://www.hyattsville.org/529/Bike-and-Pedestrian-Plan

City of Rockville. (2002). Ordinance No. 24-02. Comprehensive Master Plan. Retrieved November 18, 2020, from https://www.rockvillemd.gov/200/Master-Plan
Clean Air Act of 1970, 42 U.S.C. §7401 et seq.

DeShazo, G. (2019). *Designing light-duty vehicle incentives for low- and moderate-income households* (Rep.). Los Angeles, CA: University of California, Los Angeles, Retrieved from https://ww3.arb.ca.gov/research/single-project.php?row_id=65259

Environmental Defense Fund. (2020). *Health Impacts of Air Pollution*. Environmental Defense Fund. Retrieved from www.edf.org/health/health-impacts-air-pollution.

Environmental Justice Commission. (n.d.).*Environmental Justice Commission: Prince George's County, MD*. Retrieved from: https://www.princegeorgescountymd.gov/3238/ Environmental-Justice-Commission.

Gibson, M., & Carnovale, M. (2015). The effects of road pricing on driver behavior and air pollution, Journal of Urban Economics,Volume 89, Pages 62-73, ISSN 0094-1190, https://doi.org/10.1016/j.jue.2015.06.005. Retrieved from http://www.sciencedirect.com/science/article/pii/S0094119015000467

Giles, L. V., Barn, P., Künzli, N., Romieu, I., Mittleman, M. A., van Eeden, S., Allen, R., Carlsten, C., Stieb, D., Noonan, C., Smargiassi, A., Kaufman, J. D., Hajat, S., Kosatsky, T., & Brauer, M. (2011). From good intentions to proven interventions: effectiveness of actions to reduce the health impacts of air pollution. Environmental health perspectives, 119(1), 29–36. https://doi.org/10.1289/ehp.1002246

Gwynn, R. C., & Thurston, G. D. (2001). The burden of air pollution: impacts among racial minorities. *Environmental health perspectives*, *109 Suppl 4*(Suppl 4), 501–506. https://doi.org/10.1289/ehp.01109s4501

Harrington, W., Walls, M.A., & McConnell, V.D. (1994). Using Economic Incentives to Reduce Auto Pollution. *Issues in Science and Technology, 11*(2), 26-32.

Hogan, L. (2020). *Declaration of State of Emergency and Existence of Catastrophic Health Emergency - COVID-19* [Proclamation]. State of Maryland. https://governor.maryland.gov/wp-content/uploads/2020/03/Proclamation-COVID-19.pdf

Kjellstrom, T., Lodh, M., McMichael, T., Ranmuthugala, G., Shrestha, R., & Kingsland, S. (2006). Air and Water Pollution: Burden and Strategies for Control. Jamison, D., Breman, J., Measham, A., et al., (eds.). *Disease Control Priorities in Developing Countries*. Ch. 43. 2nd edition.

Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2006. Retrieved from: https://www.ncbi.nlm.nih.gov/books/NBK11769/ Co-published by Oxford University Press, New York.

Maryland Department of the Environment. (n.d.a). *Clean Commute*. https://mde.maryland.gov/programs/Air/MobileSources/Pages/Commute.aspx

Maryland Department of the Environment. (n.d.b). *Issued Part 70 Permits*. https://mde.state.md.us/programs/Permits/AirManagementPermits/Pages/title5_issued_permits.asp

Maryland Department of the Environment. (n.d.c.). *Title V Fact Sheet*. https://mde.state.md.us/programs/Permits/AirManagementPermits/Pages/title5factsheet.aspx

Maryland Department of the Environment. (2020-a). *Maryland Clean Cars Program*. https://mde.maryland.gov/programs/air/mobilesources/pages/cleancars.aspx

Maryland Department of the Environment. (2020-b). *Zero Emission Vehicles*. https://mde.maryland.gov/programs/air/mobilesources/pages/zev.aspx.

Metropolitan Washington Council of Governments. (2018). Equity Emphasis Areas for Transportation Planning Boards Enhanced Environmental Justice Analysis. Retrieved From www.mwcog.org/transportation/planning-areas/fairness-and-accessibility/environmental-justice/equity-emphasis-areas/

Pastor, M., Morello-Frosch, R., Ph.D, M.P.H, & Sadd, J., Ph.D. (2010). *Air Pollution and Environmental Justice: Integrating Indicators of Cumulative Impact and Socio-Economic Vulnerability into Regulatory Decision-Making* (Rep.). University of Southern California, Retrieved from https://ww3.arb.ca.gov/research/single-project.php?row_id=64727

Pratt, G., Vadali, M., Kvale, D., & Ellickson, K. (2015). Traffic, Air Pollution, Minority and Socio-Economic Status: Addressing Inequities in Exposure and Risk. *International Journal of Environmental Research and Public Health*, *12*(5), 5355–5372. doi:10.3390/ijerph120505355

Prince George’s County. (2020). Air Quality. Prince George’s County, MD. Retrieved from https://www.princegeorgescountymd.gov/1885/Air-Quality

Prince George’s County. (n.d.). Air Quality. Prince George’s County, MD. Retrieved from https://www.princegeorgescountymd.gov/338/Air-Quality.

Prince George's County (n.d.a.). Air Quality Index. Prince George's County, MD. Retrieved from https://www.princegeorgescountymd.gov/344/Air-Quality-Index.

Prince George's County (n.d.b.). Sustainable Energy. Prince George's County, MD. Retrieved from https://www.princegeorgescountymd.gov/936/Sustainable-Energy-Program.

Prince George's County (n.d.c.). Transportation. Prince George's County, MD. Retrieved from https://www.princegeorgescountymd.gov/1099/Transportation.

Prince George's County (n.d.d.). Biking/Walking Resources. Prince George's County, MD. Retrieved from https://www.princegeorgescountymd.gov/2266/BikingWalking-Resources.

Prince George's County Department of Public Works & Transportation (n.d.). RideSmart: Commuter Solutions. Retrieved from http://www.ridesmartsolutions.com/.

Prince George's County Department of Public Works & Transportation (n.d.a.). Smart Benefits. RideSmart: Commuter Solutions. Retrieved from http://www.ridesmartsolutions.com/ employer_programs/smart_benefits.

Prince George's County Department of Public Works & Transportation (n.d.b.). Carpooling. RideSmart: Commuter Solutions. Retrieved from http://www.ridesmartsolutions.com/cars_and_carpooling/carpooling

Prince George's County Department of Public Works & Transportation (n.d.c.). Vanpooling. RideSmart: Commuter Solutions. Retrieved from http://www.ridesmartsolutions.com/cars_and_carpooling/vanpooling.

*Prince George's County Environmental Justice Commission.* (2018). *(HB 183 - 2018) MSAR# 11623: Report on the Commission* (Rep.). MD: Prince George's County. Retrieved from: https://www.princegeorgescountymd.gov/DocumentCenter/View/27132/ Environmental-Justice-Commission-Report-Final-PDF

Prince George's County Traffic Division (2020). *Neighborhood Traffic Issues*. Prince George's County Department of Public Works & Transportation. Retrieved October 16, 2020, from https://www.princegeorgescountymd.gov/1062/Neighborhood-Traffic-Issue

PGC HealthZone. (2020-a). *Prince George's County HealthZone Dashboard*. Health Department Prince George's County. Accessed October 16, 2020. Retrieved from http://www.pgchealthzone.org/indicators/index/indicatorsearch?doSearch=1

PGC HealthZone. (2020-b). *2020 Demographics Summary Data for County: Prince George's.* Health

Department Prince George's County. Retrieved from http://www.pgchealthzone.org/demographicdata

Samson, P.J. (1988). Air Pollution, the Automobile, and Public Health. (Watson, A.Y., Bates, R.R., & Kennedy, D. Eds.). Washington (DC): National Academies Press (US); 1988. Atmospheric Transport and Dispersion of Air Pollutants Associated with Vehicular Emissions. Available from: https://www.ncbi.nlm.nih.gov/books/NBK218142/

Sanchez, T. W, Stolz, R., & Ma, J. S. (2003). Moving to Equity: Addressing Inequitable Effects of Transportation Policies on Minorities. *UCLA: The Civil Rights Project / Proyecto Derechos Civiles*. Retrieved from https://escholarship.org/uc/item/5qc7w8qp

Santos, G., Behrendt, H., & Teytelboym, A. (2010). Part II: Policy instruments for sustainable road transport, *Research in Transportation Economics*, Volume 28, Issue 1, Pages 46-91, ISSN 0739-8859, https://doi.org/10.1016/j.retrec.2010.03.002., Retrieved from http://www.sciencedirect.com/science/article/pii/S0739885910000223

Schuster, T., Schuster, M., Banerjee, A., Shankar, A., Byrne, J., & Glover, L. (2004). Transportation Strategies to Improve Air Quality. Retrieved from https://www.researchgate.net/publication/26990719_Transportation_Strategies_to_Improve_Air_Quality

Sustainable Maryland. (2014). Participating Communities. Retrieved November 17, 2020, from http://sustainablemaryland.com/actions-certification/participating-communities/

U.S. Department of Transportation. (2015-a) Proximity To Major Roadways. *U.S. Department of Transportation*, www.transportation.gov/mission/health/proximity-major-roadways.

U.S. Department of Transportation. (2015-b). *Expand Public Transportation Systems and Offer Incentives*. *U.S. Department of Transportation.* https://www.transportation.gov/mission/health/Expand-Public-Transportation-Systems-and-Offer-Incentives

U.S. Department of Transportation. (2015-c)."Integrate Health and Transportation Planning." *U.S. Department of Transportation*, Retrieved from: www.transportation.gov/mission/health /Integrate-Health-and-Transportation-Planning.

U.S. Environmental Protection Agency . (2020-a). *Operating Permits Issued under Title V of the Clean Air Act*. https://www.epa.gov/title-v-operating-permits

U.S. Environmental Protection Agency. (2020-b). *The Safer Affordable Fuel Efficient (SAFE) Vehicles Final Rule for Model Years 2021-2026.* *https://www.epa.gov/regulations-emissions-vehicles-and-engines/safer-affordable-fuel-efficient-safe-vehicles-final-rule*.

U.S. Environmental Protection Agency. (2019-a). *One National Program on Federal Preemption of State Fuel Economy Standards*. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100XI4W.pdf

U.S. Environmental Protection Agency. (2019-b). EJSCREEN: Environmental Justice Screening and Mapping ToolRetrieved November 18, 2020, from https://ejscreen.epa.gov/mapper/

U.S. Environmental Protection Agency. (2018-a). *Download Daily Data*. Retrieved October 14, 2020, from https://www.epa.gov/outdoor-air-quality-data/download-daily-data

U.S. Environmental Protection Agency. (2018-b). *Download Daily Data*. Retrieved October 14, 2020, from https://www.epa.gov/outdoor-air-quality-data/download-daily-data

U.S. Environmental Protection Agency. (2017-a). *Basic Information about Operating Permits*. https://www.epa.gov/title-v-operating-permits/basic-information-about-operating-permits

U.S. Environmental Protection Agency. (2017-b). *Who Has to Obtain a Title V Permit?*. https://www.epa.gov/title-v-operating-permits/who-has-obtain-title-v-permit

U.S. Environmental Protection Agency. (2017-c). *Emission Standards Reference Guide for On-road and Nonroad Vehicles and Engines*. https://www.epa.gov/emission-standards-reference-guide

U.S. Environmental Protection Agency. (2016). *Tools and Calculators | Improving Air Quality in Your Community*. EPA Archive. *https://archive.epa.gov/airquality/community/web/html/calculators.html*

U.S. Environmental Protection Agency. (2007). *The Plain English Guide to the Clean Air Act*. https://www.epa.gov/sites/production/files/2015-08/documents/peg.pdf

## Appendix

Table 1. Air Quality index for the criteria pollutants discussed in study.

| O3 (ppm) 8-hr | NO2 (ppb) 1-hr | PM2.5 (µg/m3) 24-hr | PM10 (µg/m3) 24-hr | AQI | Category |
|---|---|---|---|---|---|
| 0.000 - 0.054 | 0 - 53 | 0.0 - 12.0 | 0 - 54 | 0 - 50 | Good |
| 0.055 - 0.070 | 54 - 100 | 12.1 - 35.4 | 55 - 154 | 51 - 100 | Moderate |
| 0.071 - 0.085 | 101 - 150 | 35.5 - 55.4 | 155 - 254 | 101 - 150 | Unhealthy for sensitive groups |
| 0.086 - 0.105 | 151 - 200 | (55.5 - 150.4)^3 | 255 - 354 | 151 - 200 | Unhealthy |
| 0.106 - 0.200 | 201 - 300 | (150.5 - 250.4)^3 | 355 - 424 | 201 - 300 | Very unhealthy |
| -2 | 301 - 400 | 250.5 - 350.4)^3 | 425 - 504 | 301 - 400 | Hazardous |
| -2 | 401 - 500 | (350.5 - 500.4)^3 | 505 - 604 | 401 - 500 | Hazardous |