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Urban Sprawl Ain't Equal Y'all: The Social and Environmental Interplays of North Carolina's Growth

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Abstract

As North Carolina undergoes rapid urbanization, this research paper aims to analyze the social and environmental impacts associated with this transformative process. The study delves into the evolving landscape of urban counties across the state. The research considers the implications for both the human population and the environmental consequences of urbanization, focusing on alterations in land use and ecological balance. The research employs regression models to analyze demographic trends, socio-economic disparities, and environmental implications in urban areas across North Carolina. An examination is given to the inequitable distribution of hazardous waste sites and exposure to air pollution, illuminating the systemic nature of these injustices. This study emphasizes the importance of implementing more equitable and inclusive urban development techniques to promote sustainable resilient communities in North Carolina and other communities in the Southeastern United States.

Keywords: environmental racism, North Carolina, pollution, sustainability, urbanization

Introduction

Over the past few decades, cities across the Southeast United States have experienced a marked trend towards urbanization, fueled by industry expansion and the promise of new professional and economic opportunities. This wave of growth has brought a surge in infrastructural projects and construction expeditions, ranging from expansive highways and new tram lines to a sharp increase in housing development. Southern cities, particularly in North Carolina, are evolving into more metropolitan hubs. Raleigh and Charlotte are prime examples of this transformation, with both cities witnessing significant growth in population and housing density. Notably, Raleigh was the second fastest-growing urban area in the United States over the last decade for cities with populations of one million or more (Cline, 2023). As of April 1, 2020, Raleigh had emerged as North Carolina's second-largest urban area, trailing only Charlotte, which remains the largest with a population exceeding 1.3 million people (Cline, 2023).

However, this demographic shift has profound implications for the delineation of major cities and smaller municipalities. Often overlooked in the examination of county-level demographic changes is the critical issue of land classification, which has a direct impact on the lives of residents, particularly in Black and Brown neighborhoods. These communities have historically been subjected to discriminatory practices that adversely affect their health and well-being. Inequitable policies that permit industrial pollution near low-income and minority neighborhoods result in these communities facing disproportionately high exposure to hazardous environmental conditions. Consequently, they often lack access to essential resources such as green spaces, clean water, and adequate healthcare services, further compounding their challenges. These marginalized populations frequently lack the political and economic power necessary to counteract the detrimental effects of these environmental hazards (Henderson et al., 2021).

This paper poses the question: Does urbanization exacerbate the environmentally toxic hazards that disproportionately impact minority communities? Through empirical investigation and holistic analysis, this research aims to uncover the direct environmental impacts of urban planning in communities of color across all North Carolina counties. As North Carolina continues to grow and develop, these communities have heightened risks towards health and overall wellness in urban areas. Factors such as race and class play key roles in the decision-making processes driving urban development.

I, as a North Carolina native who grew up experiencing the growth of Raleigh first-hand, have some understanding of the interplay between urbanization and the deterioration of the surrounding environment. Working in environmental justice has also taught me about past advocacy efforts in North Carolina to combat the decline of greenspaces. During my matriculation in undergraduate education, my research surrounding Southern urban practices and their impact on Black communities began with an analysis of Hurricane Katrina in New Orleans, Louisiana (Waddell, 2023). The level of disaster for Black and Brown communities was exacerbated due to inadequate public transportation, the locations of hazardous waste sites, and racialized districting. Examining the systematic factors at work in such a devastating story pushed me to take a different approach to uncovering the social interplays behind environmental racism in North Carolina.

The deliberate placement of hazardous waste dumps and polluting businesses in minority and low-income communities has exacerbated environmental inequality. These facility sites have had a negative impact on public health, including an increase in the prevalence of asthma, cancer, and other illnesses in vulnerable populations. These communities typically lack the political and financial means required to mitigate the effects of environmental hazards. As North Carolina grows and develops, a rising number of people are being displaced from their homes, creating new risks to health and overall well-being in urban areas.

This research will present literature that describes and discusses the environmental consequences of inequitable processes. Following that, we will discuss the hypothesis and theory that support the empirical framework. The data and methodology will be thoroughly described, with visual aids to support the analysis. The paper closes with discussions about limits and future research.

Supporting Literature

As a foundation for this research, a meticulous literature review was conducted to identify existing research but also evaluate strengths, and weaknesses, and discern potential gaps in knowledge. Databases such as JSTOR and Google Scholar were utilized to identify relevant and reliable sources to build and enhance the research design. When collecting secondary data from reliable sources, there were a plethora of articles and journals referencing environmental injustice in southern communities, primarily focusing on the Gulf Coast. Each entry provided a useful framework to draw educated inferences in the case of the systems in play for North Carolina.

How Do We Look at Urban vs Non-Urban?

Identifying urban and non-urban regions in the United States requires a set of criteria that take into account both demographic and geographical characteristics. Urban areas are often defined by a high population density as well as the availability of infrastructure and services associated with urban living. According to rural sociologist David Brown, the growth of urbanization involves considerable transformations in economic and social systems, indicating a transition from rural to urban lifestyles (Brown, 1979). In contrast, non-urban regions, sometimes known as rural or suburban, have lower population density and more scattered settlement patterns. The distinction between urban and non-urban areas differs by region and is determined by factors such as land use and housing density. For example, in North Carolina, urban regions are defined by specified thresholds, such as a minimum population size of 5,000 people and a concentration of 2,000 densely packed housing units, reflecting the state's distinct demographic and developmental tendencies (Cline, 2023).

The Census Bureau emphasizes housing density as a critical indicator for assessing urban development over time. Unlike population counts, housing units provide a stable measure of urbanization trends because they represent enduring infrastructure that supports residential settlement (Ratcliffe, 2022). This distinction emphasizes the need to take into account both population and housing trends when defining urban and non-urban regions. Furthermore, urban area identification takes into account functional qualities such as economic activity, transportation networks, and social infrastructure, in addition to numerical criteria. These

elements all contribute to establishing the physical size and borders of urban areas, showing the complexities of classifying regions as urban or non-urban in the United States.

Demographic Changes in the Southeast

The minimum number of people required to qualify an area as urban has almost doubled over the past century, specifically in the Southeast—the region that spans from the Appalachian Mountains to expansive coastal plains (Carter, 2014). It is said that on average, most newly designated metropolitan areas are located in the Southeastern region due to changes in economic development and professional opportunity (Brown, 1979). As populations become more condensed into a specific region, residents of rural and suburban areas are more likely to witness a decline in nearby job opportunities and increase their travel to better-paying jobs. Sociologists often use long-distance commuting to jobs as an efficient empirical measure of urban influence on towns and municipalities (Cromartie, 2006). According to demographic data, nonmetro-to-metro transfers have disproportionately impacted the rural and suburban South. Over the last 75 years, the area has had the sharpest reduction in the share of its inhabitants residing in nonmetro counties (Cromartie, 2006). This shift has major implications for the racial makeup of these areas. Typically, metropolitan counties have the highest percentage of racial minority populations, specifically Black and Brown people (Brown, 1979). Mapping data shows that today Black Americans are still highly represented in urban areas in the South (See Image 3). This is often traced back to the historical legacy of slavery where newly emancipated Black people continued to live in the Southern region due to economic and social ties. As the southern states underwent industrialization and economic development, notably during and after World War II, the expansion of manufacturing and agriculture drew Black workers to cities where job possibilities were more plentiful. However, research has shown that the past and the ongoing condensed placement of Black people in urban areas has deliberate implications.

What is Environmental Racism?

These implications manifest in environmental disadvantages towards Black and Brown communities that are carried out through policy and unethical business practices (Bullard, R. D., 1994). Environmental racism encompasses infrastructural violence, which is violence caused by infrastructures that determine access to and quality of resources and services (Henderson et.al., 2021).

The lens of environmental justice uncovers that the impact of inequitable housing practices, economic disinvestment, industrial pollution, and poverty are not unrelated. Exclusionary housing policies exacerbate housing inequality, exposing Black communities disproportionately to environmental contaminants and separating them from key health services including healthy food alternatives, hospitals, pharmacies, and green spaces. These damaging practices are reinforced by government, legal, and economic institutions and are exacerbated in urban areas (Henderson et.al., 2021). Inequitable access to vital resources in the urban built environment has been identified as a serious societal issue.

Increased Consequences of Environmental Racism

Results from urban and environmental justice studies that conceptualize racism as a structural component that determines environmental inequality show that predominately Black communities are more than twice as likely to be resource deserts. Furthermore, largely Black communities are roughly three times more likely than other neighborhoods to experience severe, compounded resource constraints (Satcher, 2022). Minority communities have also been reported to be disproportionately placed near local incinerators, sewage treatment plants, and other public facilities (Gelobter, 1994). These populations are more exposed to pollution and toxic chemicals, posing greater health hazards. This can lead to an increase in respiratory disorders, cardiovascular illness, and other health concerns among inhabitants.

Pollutants released into the air by incinerators and industrial sites can have an impact on local air quality. Poor air quality has been related to respiratory issues such as asthma and can aggravate pre-existing health concerns. Studies have shown that on average, 65% of African Americans and 80% of Hispanics live in 437 counties with substandard air quality (Bullard, 2015). In urban areas where long-distance commuting is prevalent, this specific threat is prevalent. In cities, minorities and low-income families are disproportionately likely to live near a major road with high traffic flow, where TRAP (transportation-related air pollutant) concentrations, such as nitrogen, are often the greatest (Clark et.al., 2017). This has persisted in the United States over time with a recent U.S. cohort study reporting that estimated nitrogen concentrations from 1990 to 2009 were 10% higher for Blacks and Hispanics than whites, even after controlling for individual socioeconomic characteristics and metropolitan area characteristics (Clark et.al., 2017). The majority of these inequities can be identified on a case-by-case basis by examining this phenomenon in specific locations. However, it seems that the same conclusion can be drawn: urbanized or developing areas seem to lead to heightened exposure to environmental hazards for minority communities. There has been little research done in North Carolina on this social-environmental correlation, leaving much up to inference and primary evidence. This research aims to explore this phenomenon through primary data collection and analysis.

Theory and Hypothesis

Despite the vast documental evidence surrounding the intersections of urbanization and environmental injustice, especially in the Southeastern region, very little research has been done in North Carolina on this social-environmental correlation. Much of the scope surrounding environmental justice, from a grassroots and research standpoint, is centered around the business of rural and municipal communities. This can be attributed to North Carolina's dominant agriculture and hog industry, with over 8 million farming acres and over 40,000 farms spread across 100 counties (USDA, 2022). Incidentally, it was the embedded hazards in rural Warren County that gave birth to environmental advocacy. In 1982, protesters actively fought against the state government's decision to place a hazardous landfill in proximity to the predominantly Black community that dominated Warren County at the time (Henderson et.al., 2021).

While staying true to the history of the movement and the state, it is crucial to broaden the scope of environmental justice beyond the status quo and apply an empirical framework to the evolution of the state's demographics. The gap that this theory aims to address is the lack of empirical coverage about the environmental interplays within urban North Carolina. As

previously stated, North Carolina is experiencing significant growth in both population and infrastructure. Over the last decade, cities like Raleigh and Charlotte have grown with urban areas of a million or more people. To this day, the Charlotte urban area remains the largest urban area located in North Carolina with a population of over 1.3 million people (See Image 1).

Urban Area ↑↓	Population ↑↓	Housing Units ↑↓	Land Area (Sq. Mi.) ↑↓	Water Area (Sq. Mi.) ↑↓	Population Density ↑↓
Charlotte, NC-SC **	1,359,439	567,807	642.29	10.24	2,116.56
Raleigh	1,106,646	455,527	554.82	5.36	1,994.61
Winston-Salem	420,924	187,144	310.79	2.11	1,354.37
Durham	396,118	173,410	183.36	1.31	2,160.39
Greensboro	338,928	148,331	169.31	2.17	2,001.85

Image 1. Source: Michael Cline, 2023.

This population increase has been correlated with counties in North Carolina growing more urbanized over time. Both Wake County—the county with the city of Raleigh—and Mecklenburg County—the county with the city of Charlotte—have experienced expansions in population by approximately 25% within the previous decade (See Image 2). While this development has been correlated with economic growth in underdeveloped regions and industry expansion, this has also led to disproportionate environmental exposure to marginalized areas. The correlation between urbanization and environmental inequality is evident in North Carolina's major urban centers. For example, studies indicated that minority communities in cities like Charlotte and Raleigh are more likely to be situated near highways and other sources of environmental pollution (Wilson et al., 2012). These patterns mirror the broader trends observed at the national level, reinforcing the hypothesis that urban development disproportionately impacts minority communities in terms of environmental hazards.

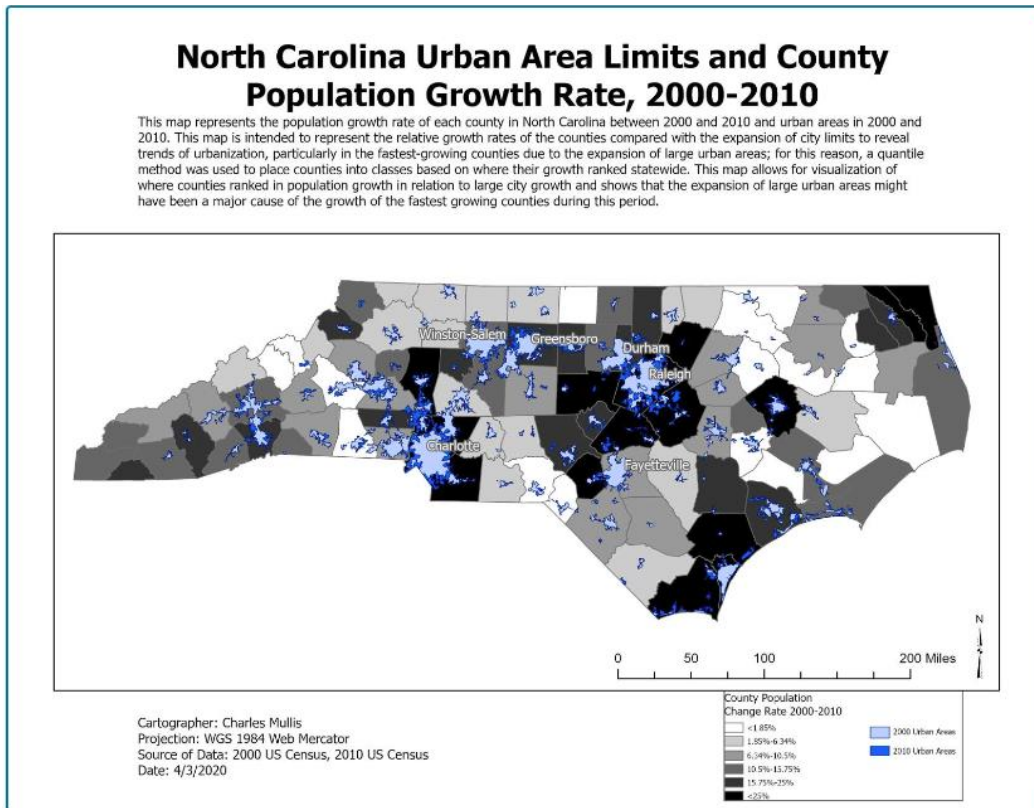


Image 2. Source: Charles Mullis, 2020

Urban sprawl often results in longer commuting distances as residential areas spread further away from commercial and industrial hubs. This sprawl necessitates extensive commuting, predominantly by car, which leads to increased highway usage and traffic volumes, with major highways experiencing major congestion. Prior texts have established that the increased use of vehicles for commuting and transportation leads to higher emissions of greenhouse gases, exposing marginalized communities to higher levels of traffic-related air pollution. This finding is consistent with patterns observed in North Carolina, where many minority communities are situated near congested highways and transportation hubs. My theory, which is contingent on existing research and first-hand evidence, poses the hypothesis:

H1: The presence of urban development increases the likelihood of minority communities being directly impacted by environmentally toxic hazards.

Using this hypothesis to build an empirical framework centered around North Carolina can influence local policy by highlighting the need for more comprehensive urban planning that addresses the unique environmental risks faced by urban dwellers, particularly those in marginalized communities. It can also spur the adoption of more stringent environmental regulations and the development of sustainable urban policies that align with the broader goals of environmental justice. necessitates updating our theories to account for these developments and aligning them with queries prompted and answered by existing literature.

Data and Methods

This research utilizes two federal datasets: The Environmental Protection Agency's 2023 EJ Screen Data (EPA) and the United States Department of Agriculture's 2023 Rural-Urban Continuum Codes (USDA). The EJScreen offers a high-resolution geographic overview of environmental and demographic data across the United States, focusing on places with higher environmental burdens and vulnerable populations. The tool combines multiple indicators using Census block groups as the primary geographic unit, offering insights through color-coded maps and standard data reports. The socioeconomic data used in EJScreen is based on the U.S. Census Bureau's American Community Survey (ACS) 2017-2021 5-Year Estimates (ACS 2021). The dataset encompasses a total of 242,335 Census block groups. The USDA Rural-Urban Continuum Codes (RUCC) dataset is used to classify urbanization levels across counties in North Carolina. The 2023 RUCC distinguishes U.S. metropolitan counties by population size and nonmetropolitan counties by their degree of urbanization and adjacency to metro areas. This classification provides a binary system to delineate urban and rural regions, enabling a straightforward comparison of urbanization impacts on environmental and demographic factors. Both datasets were merged and filtered to display information about North Carolina and from there, the independent and dependent variables for this research were identified.

The first independent variable is marginalization. Marginalization is quantified using a Demographic Index from EJScreen, which combines the percentage of people of color¹ and the percentage of low-income populations². To calculate the percentage of people of color, the EPA takes the total population of a region minus white people over the total population³. To calculate the percentage of low-income households, the EPA takes the total population of which poverty status is known minus people with a ratio of income to poverty from 2.00 and over⁴ the total population. Those two values are then combined and divided by two to determine the demographic index. For example, if a Census block group has a low-income indicator value of 25% and a people of color indicator value of 75%, the Demographic Index value would be 50%. This combination served as a comprehensive measure of demographics on an intricate, block level that ranged from 0% to 100%. This data measure was scaled to operate on a base 0 to 1 ratio. This research used their demographic index to represent marginalization as it is a comprehensive model that captures both the rates of minority communities that are underrepresented and do not have the means to counteract the environmental factors that disproportionately impact them.

The second independent variable was urbanization. Urbanization is quantified by the USDA's measurement and organization of U.S. counties. The 2023 Rural-Urban Continuum Codes distinguishes U.S. metropolitan counties by the population size of their metro area, and nonmetropolitan counties by their degree of urbanization and adjacency to a metro area. For

¹ Defined as individuals who list their racial status as a race other than white alone or who list their ethnicity as Hispanic or Latino. This group includes all individuals except non-Hispanic white-alone individuals.

² Households with an income less than or equal to twice the poverty level, for instance, a household of four with an annual income below \$52,992.

³ Total populations are determined by Census Bureau FTP Server

⁴ The socioeconomic data source is U.S. Census Bureau's American Community Survey (ACS) 2017-2021 5-Year Estimates (ACS 2021)

Rural-Urban Continuum Codes 1 to 3, metro counties were divided into three categories according to the total population of the metro area of which they are part: 1 million people or more (code 1), 250,000 to 1 million people (code 2), and below 250,000 (code 3). Nonmetro counties are classified along two dimensions. First, they are divided into three urban-size categories: an urban population of 20,000 or more (codes 4 and 5), 5,000 to 20,000 (codes 6 and 7), and fewer than 5,000 (codes 8 and 9)⁵. For simplicity and comprehension, this measurement scale was rotated and mutated to a scale of 0 to 8 with 0 representing peak rurality and 8 representing the most urban. With an exact zero determined, this scale was mutated once again to represent a ratio of 0 to 1, mimicking the scale of the previous independent variable. This method aimed to promote continuity and cohesion within the data analysis process.

The dependent variables for this experiment were Air Toxics Cancer Risk, Toxic Releases to Air, and Hazardous Waste Proximity. Data on air toxics cancer risk is sourced from the EPA's 2019 AirToxScreen. This indicator estimates the lifetime inhalation cancer risk from carcinogens in ambient outdoor air, presented as persons per million over a 70-year lifetime. The values are initially reported at the Census tract level and then assigned to corresponding block groups. The percentiles used to represent air toxic cancer risk range from 0 to 100%, with higher values indicating higher cancer risks. The Toxic Releases to Air indicator, provided by the EPA's Office of Pollution Prevention and Toxics (OPPT), quantifies potential human health impacts from chemical releases into the air. The data is derived from the 2021 Risk-Screening Environmental Indicators (RSEI) and is expressed in toxicity-weighted concentration values. These values are aggregated at the Census block group level and represented in percentiles, ranging from 0 to 100%. Hazardous waste proximity data is sourced from operating Treatment, Storage, and Disposal Facilities (TSDFs) and Large Quantity Generators (LQGs) as reported in the 2021 Biennial Reports (BR). This indicator measures the population-weighted proximity to hazardous waste facilities within 5 km of the average resident in each block group. The values range from 0.00075 to 74.7876 and are represented in percentiles from 0 to 100%. Air toxic cancer risk is used to demonstrate an example of the negative health effects that come from environmental racism. Both the toxic releases to the air and the hazardous waste proximity were used to demonstrate the correlation between urban areas and increased pollution to support the hypothesis.

Both the EPA—an agency that sets the standard for national environmental concerns and relies on frequent scientific information—and the USDA—a federal agency that heavily focuses on economic and agricultural research—present major strengths to this research model with their data. However, their databases delve into the scope of limitations. The EPA's EJScreen is not a detailed risk analysis. It is a screening tool that examines some of the relevant issues related to environmental justice, and there is uncertainty in the data included. The second important limitation is that EJScreen relies on demographic and environmental estimates that involve substantial uncertainty. This is especially true when looking at a small geographic area, such as a single Census block group. A single block group is often small and has uncertain estimates. This is why this research will look at all county-block groups within North Carolina to be as

⁵ USDA, Economic Research Service using data from the Office of Management and Budget and U.S. Department of Commerce, Bureau of the Census.

accurate as possible. All indicators are calculated for each block group. The USDA's RUCC has some inconsistencies. Changes to criteria used by OMB to define metro areas and by the U.S. Census Bureau to define urban areas have affected the delineation of the RUCC over the past five decades. Between 2013 and 2023, the U.S. Census Bureau modified its criteria for delineating urban areas in two ways. First, housing unit density replaced population density as the primary statistic to distinguish urban and rural territories. Second, the minimum size to qualify to be an urban area changed from 2,500 people to 2,000 housing units or 5,000 people. This served to increase the rural population overall and to increase the number of counties with fewer than 5,000 urban population (codes 8 and 9). However, these changes are still consistent with the methods of identifying more urban or rural populations in North Carolina and it creates a binary identifying system to complete the necessary analyses.

This experiment examined the correlation between urbanization, marginalization, and the dependent variables to identify potential linear relationships. I then conducted multiple linear regression analyses to quantify the relationship between the dependent and independent variables. Separate models were run for each dependent variable to assess their specific impacts.

Results and Analysis

Model 1

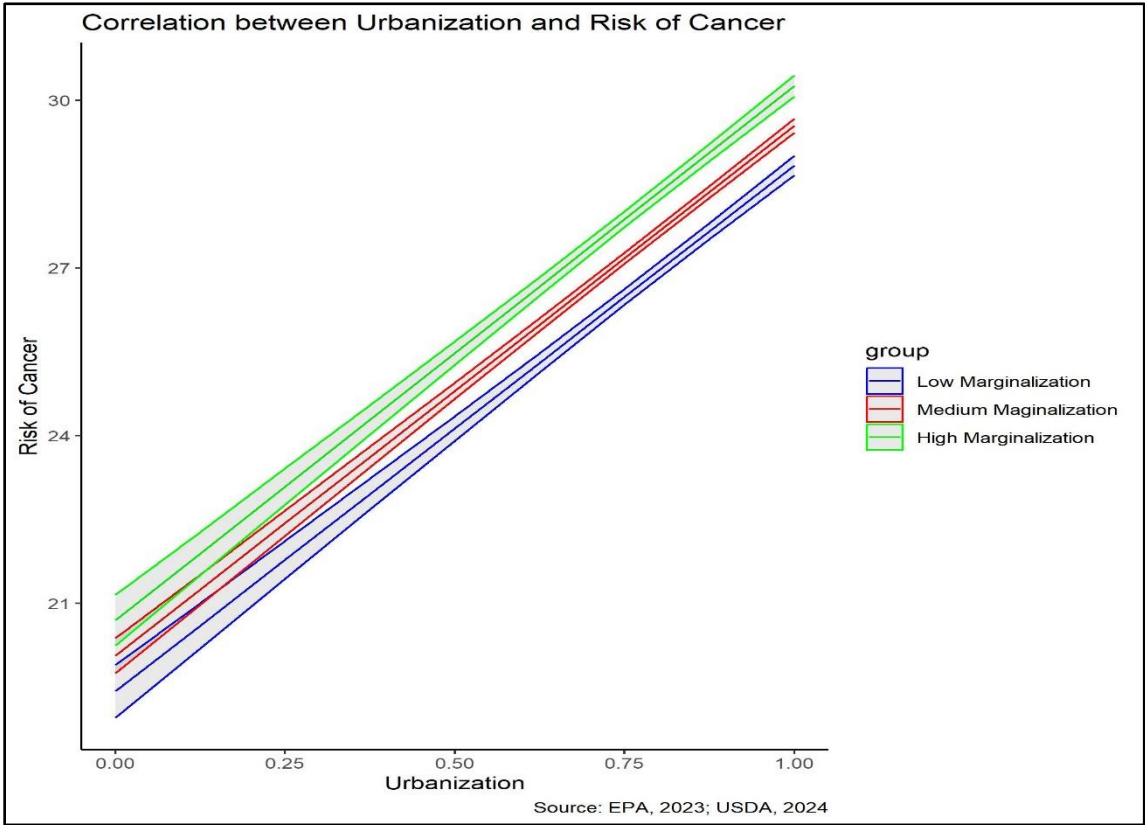
Table 1: Cancer Regression Model	
	<i>Dependent variable:</i>
	CANCER
	Predictor
Marginalization	3.020*** (0.823)
Urbanization	9.345*** (0.407)
UrbanxMarginalization	0.377 (0.995)
Intercept	18.977*** (0.342)
Observations	7,090
R ²	0.261
Adjusted R ²	0.261
Residual Std. Error	4.199 (df = 7086)
F Statistic	834.138*** (df = 3; 7086)
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01

In this model, the risk of cancer from being exposed to air toxins is our dependent variable. Both the Demographic Index and Urbanization coefficients have very low p-values (< 0.001), indicating that their relationships with cancer risk are statistically significant. This suggests that urban areas with higher percentages of low-income individuals and people of color have higher cancer risks. We can reject the null hypothesis in this model. Although both urbanization and demographic factors individually increase cancer risk, their combined interaction does not show a significant additional effect, suggesting that the effects of these factors on cancer risk are largely additive and independent

of each other.

However, after running a predicted effects model, Figure 1 demonstrates a positive correlation between the risk of cancer, marginalization, and urban areas. It appears as groups with a higher marginalization appear in more urban environments, there is a higher cancer risk. This also supports our hypothesis.

Figure 1



Source: United States Environmental Protection Agency, 2023; United States Department of Agriculture, 2024.

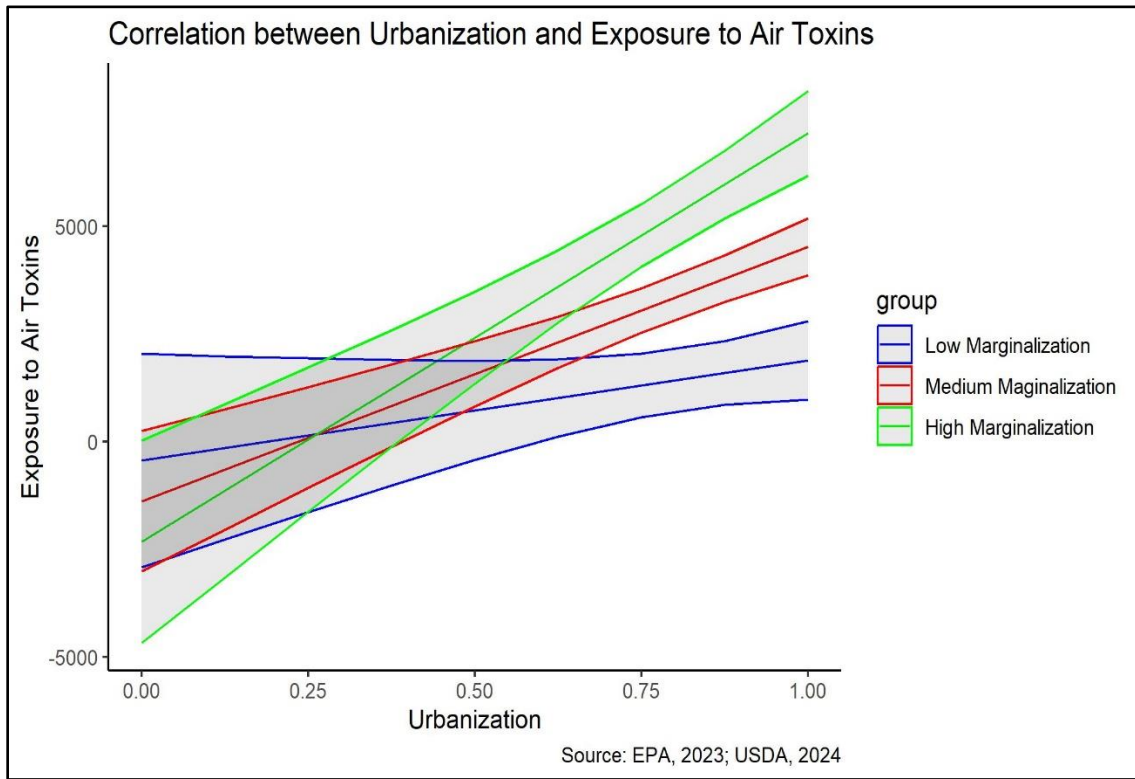
Model 2

In this model, the presence of toxicity-weighted concentrations in the air is our dependent variable. While both the Demographic and Urbanization coefficients have negative values, implying a negative relationship between the independent and dependent variables, the values are not significant. The only significant value in this model is the interaction between independent variables. This implies that the combined effect of marginalization and urbanization on air toxicity is significant, with the toxicity-weighted concentrations increasing significantly when both factors are high.

This can be displayed properly in Figure 2 with high proportions of low-income and minority populations appearing to significantly higher toxicity-weighted air pollutant concentrations. The significant interaction term implies that the effect of demographic factors on air toxicity is different in urban versus rural areas. Specifically, urban areas with higher percentages of low-income and minority populations are associated with significantly higher air toxicity, highlighting a potential environmental justice issue where these populations may be more exposed to harmful air pollutants in urban settings. This interpretation allows us to reject the null hypothesis as it points to a nuanced relationship where the convergence of urban settings and disadvantaged demographic groups leads to heightened air pollution risks.

	<i>Dependent variable:</i>
	RSEI_AIR Predictor
Marginalization	-4,498.932 (4,330.378)
Urbanization	-235.405 (2,143.860)
UrbanxMarginalization	17,056.090*** (5,219.933)
Intercept	236.468 (1,805.663)
Observations	7,083
R ²	0.013
Adjusted R ²	0.013
Residual Std. Error	21,765.890 (df = 7079)
F Statistic	30.891*** (df = 3; 7079)
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01

Figure 2



Source: United States Environmental Protection Agency, 2023; United States Department of Agriculture, 2024.

Model 3

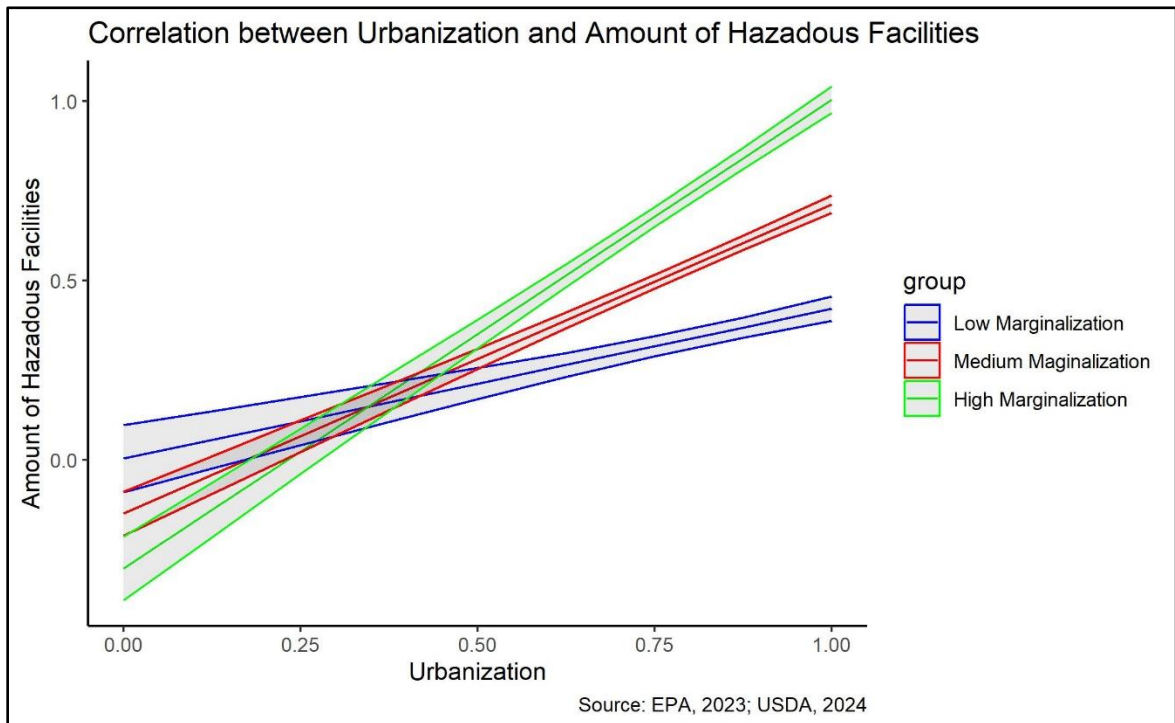
Table 1: Hazardous Waste Regression Model	
	<i>Dependent variable:</i>
	PTSDF Predictor
Marginalization	-0.730*** (0.163)
Urbanization	0.100 (0.081)
UrbanxMarginalization	2.119*** (0.197)
Intercept	0.113* (0.068)
Observations	7,076
R ²	0.123
Adjusted R ²	0.122
Residual Std. Error	0.819 (df = 7072)
F Statistic	330.139*** (df = 3; 7072)
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01

In the final model, the count of hazardous waste management facilities within 5 km of a location represents the dependent variable. The only coefficient that did not display significance was the urbanization variable, suggesting that urbanization alone does not have a significant direct impact on the number of hazardous waste facilities when not considering the interaction with demographic factors. However, both the marginalization and interaction coefficients are statistically significant. This implies there is an effect of marginalization on the count of hazardous waste facilities that changes significantly with different levels of urbanization.

Once again, a predicted effects model can display the correlation between each of these variables, as seen in Figure 3. The

significant positive interaction term indicates that in urban areas, the effect of marginalization on the count of hazardous waste facilities is markedly different. Specifically, areas that are both urban and have higher proportions of low-income and minority populations tend to have significantly more hazardous waste facilities. This suggests that in urban settings, these demographic groups may be more exposed to environmental hazards such as hazardous waste facilities, reflecting potential environmental injustice where vulnerable populations bear a disproportionate burden of environmental risks. This allows us to reject the null hypothesis once again.

Figure 3



Source: United States Environmental Protection Agency, 2023; United States Department of Agriculture, 2024.

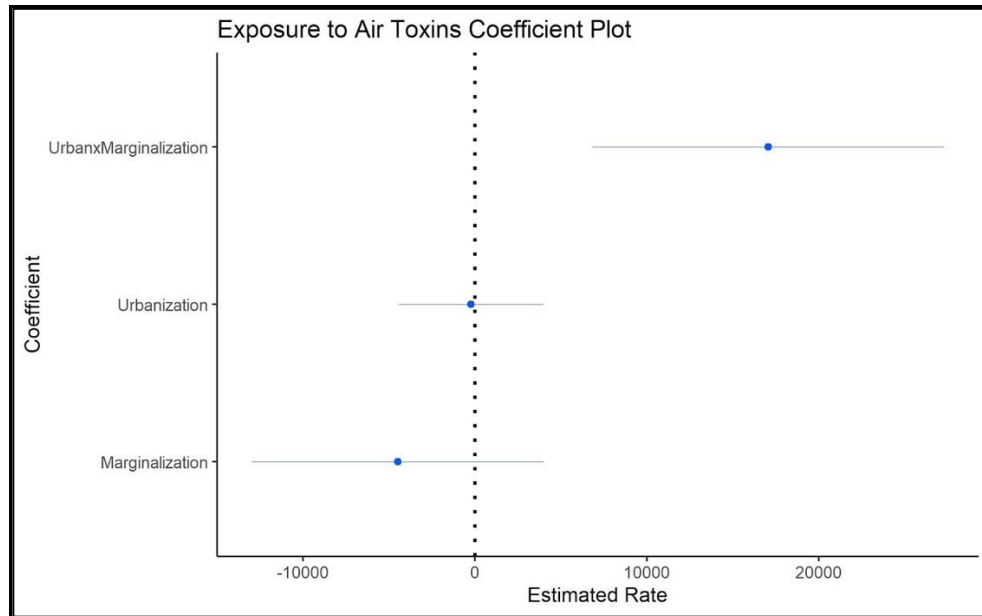
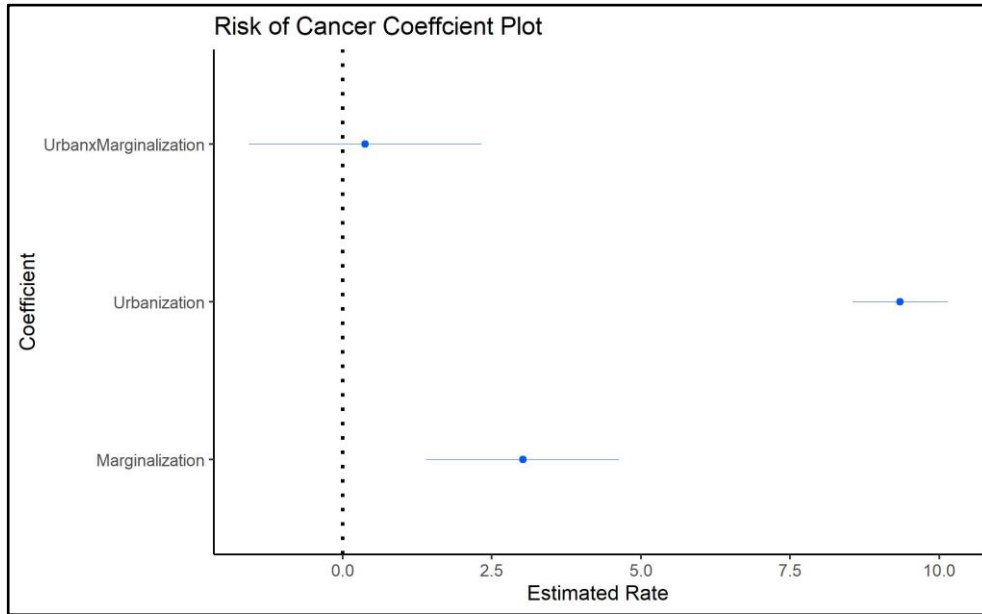
Results and Analysis

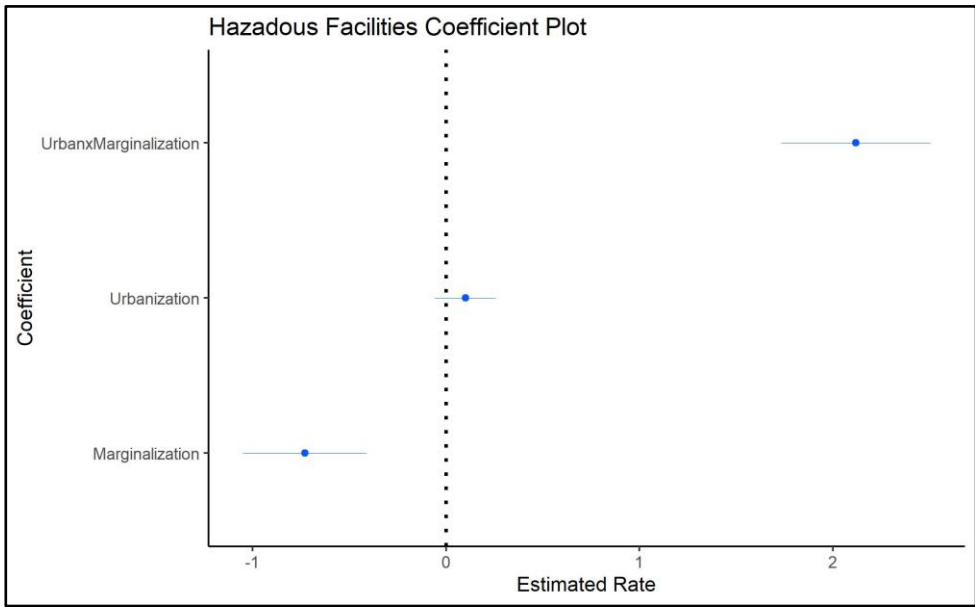
To investigate the correlation between urbanization and the increased presence of environmental hazards for minorities, this study ran three regression models to see if specific hazards or health outcomes were impacted by the location and demographics of the area. This study's findings reveal that there is indeed a very strong relationship between the urban development of an area and the impacts of environmental hazards. However, some models proved that these relationships are contingent on the interaction between marginalization and urbanization and cannot be determined by the two singularly. This study was limited in dependent variables to run to show the urban-environmental correlation. Focusing on a broader range of health outcomes and environmental variables, such as noise pollution, access to green areas, and socio-psychological stressors, might give a more complete picture of urban-environmental interactions. The study's findings rely on the accuracy and completeness of the environmental and demographic data collected. Inconsistencies or gaps in the data may have an impact on the results' soundness. Given the Census Bureau's newly revised features for distinguishing between urban and non-urban areas, the USDA's data may have errors that affect significant readings.

Despite these limitations, it is important to emphasize that the current study serves as a foundational step in a broader research agenda. Further expansion in municipalities and suburban areas will continue to affect the housing inequity, elimination of greenspaces, and major traffic patterns. Such variables, which are perpetuated through legislative and business practices, will continue to disproportionately affect vulnerable Black and Brown people. Through personal testimony and linear data modeling, these findings will highlight the complexities of urban growth, indicating that although metropolitan growth creates economic opportunity and infrastructure development, it also exacerbates environmental concerns and social disparities. Addressing these concerns requires legislators, urban planners, and community stakeholders to take a comprehensive and inclusive approach. Sustainable development methods should prioritize environmental protection, promote social fairness, and actively involve people in decision-making processes. By pushing for equitable social and economic progress in North Carolina, perhaps the state may set the road for a more sustainable and fair future for other locations in the Southeast.

Appendix

Coefficient Plots :





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