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GREENING THE STEEL CITY:

TESTING FOR ENVIRONMENTAL GENTRIFICATION IN ALLEGHENY COUNTY

A Thesis in

Energy, Environmental, and Food Economics

by

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ABSTRACT

Environmental, green, or ecological gentrification is the process whereby improvements in local environmental amenities—such as new green spaces or the cleanup of a locally undesirable land use (LULU)—either cause or exacerbate gentrifying processes. This a direct threat to the progress of the environmental justice movement whereby residents of low-income neighborhoods and communities of color face the highest possibility of displacement, negating any benefits of environmental improvements for these populations. This paper provides evidence of racialized displacement from 1990-2010 due to environmental cleanups in Allegheny County, PA. By investigating the cleanup of EPA Toxic Release Inventory facilities in Allegheny County, this paper explores how the benefits of environmental cleanups can differ by group. Specifically, this study shows how environmental cleanups in a postindustrial region can affect neighborhoods' size, median income, and racial composition. Using a differences-in-differences design, this paper, while finding somewhat mixed evidence of the scale and income effects, finds compelling evidence of a racial composition effect. On average, the complete cleanup of a neighborhood between 1990-2000 is associated with a 1.1 percentage point decrease in the change in the share of black households, with seeming replacement by white households. This is contextualized by an average 0.6 percentage point increase in the share of blacks among all communities from 1990-2000. Yet, from 2000-2010 environmental cleanups were not found to have a statistically significant impact on racial composition.

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Chapter 1

Introduction

The United States has a long history of environmental racism and injustice (United Church of Christ Commission for Racial Justice, 1987; Taylor, 2000; Taylor, 2014). While grassroots organizations and government bodies have worked to integrate environmental justice into policy and planning, evidence still suggests that low-income neighborhoods and communities of color are disproportionately exposed to environmental hazards. Even when environmental cleanups are enacted, there is a growing body of evidence to suggest that these cleanups do not benefit everyone equally. This paper provides evidence of racialized displacement from 1990-2010 due to environmental cleanups. By investigating the cleanup of EPA Toxic Release Inventory facilities in Allegheny County, PA, this paper explores how the distributional effects of environmental cleanups can differ by group. Ultimately, this displacement serves as another form of environmental injustice, whereby, black households are displaced by white households following a cleanup.

Building upon existing literature in environmental migration, residential sorting, and environmental gentrification (Banzhaf & Walsh, 2008; Crowder & Downey, 2010; Gamper-Rabindran & Timmins, 2011), this paper offers a quantitative case study to investigate the critical, but under analyzed racial composition effects of environmental improvements. While Tiebout's sorting model (1956) does not take into account considerations of race, this paper uses the Racial Income-Inequality thesis (Crowder & Downey, 2010) to expand upon Tiebout's work in order to formulate clear predictions for how different racial groups may respond to environmental improvements. The addition of the Racial Income-Inequality thesis allows for the consideration of how systematic differences in access to resources between different groups can

affect mobility. This is critical in deconstructing not only preferences for environmental quality, but the constraints that hinder the achievement of higher levels of environmental quality.

Through the use of secondary data, this paper implements a simple, but useful model to assess the impact of changes in environmental exposure on neighborhood demographics, including community size (scale), income, and racial composition. This quantitative approach is largely based on the difference-in-difference design in the seminal paper on environmental gentrification by economists Banzhaf and Walsh (2008).

Allegheny's rich history and legacy in industrial manufacturing make it a particularly interesting case study. Pittsburgh, the seat of Allegheny County, was once known as the Steel City, yet it is now being recognized for achievements in sustainability. This paper is one of the first to focus specifically on a case study in the Rust Belt and to explore environmental gentrification caused by environmental cleanups in a postindustrial region. Using the EPA's Toxic Release Inventory data, this paper seeks to understand how the cleanup and shut down of toxic facilities in Allegheny County affected neighborhoods from 1990-2010. The hope is that this study will reveal insights about population, income, and racial change caused by environmental cleanups. This study can also serve as the foundation for future work in Pittsburgh and Allegheny County in both further quantitative or qualitative work.

To contextualize the results of this paper, the following section provides an overview of environmental gentrification as it pertains to environmental justice, and how it has been investigated. There is also an introduction to Allegheny County, PA, the region's history, and current trends in sustainability. Following this review, Tiebout sorting and the Racial Income-Inequality Thesis are further elaborated on to provide theoretical predictions for this paper's model. Finally, there is a description of the empirical model, and the presentation of the results broken down by the three key areas of interest, the scale, income, and composition effects.

Chapter 2

Background

Environmental Gentrification

A central premise of the environmental justice movement (EJM) is that all people, regardless of class, race, nationality, or faith, have the right to a clean and healthy environment (Bass, 1998; Cole & Foster, 2001; Taylor, 2014; Skelton & Miller 2017). Throughout much of the United States' history, evidence has consistently shown that low-income and communities of color have disproportionally been exposed to environmental hazards, while simultaneously being spatially and socio-economically barred from environmental amenities (United Church of Christ Commission for Racial Justice, 1987; Anderton et al, 1994; Downey, 1998; Boone et al, 2009; Crowder & Downey, 2010). This has frequently resulted in higher rates of cancer, asthma, and other health issues for already systematically disenfranchised and vulnerable groups (Maantay, 2007; Collins et al., 2011, Taylor, 2014). In contrast to this discriminatory history, there is also a long history of these groups advocating for environmental justice. The first national coalition of African Americans to advocate against environmental injustices was organized and led by Martin Luther King Jr. during the 1960's (EPA, 2017). Further, concern over exposure to environmental pollution predates the EJM (Taylor, 2000). Yet, it is within this specific movement that mass attention was focused specifically on the injustices caused by corporate and governmental bodies and their interaction with systematic discrimination on the basis of "race, class, and gender" (Taylor, 2000). As the U.S. environmentalism movement progressed, and the understanding that human interactions with the environment can not only degrade the natural world, but also hurt other humans (Taylor, 2000), government agencies adopted policies focusing on pollution

abatement, environmental health, and environmental injustice (Bass, 1998). These concerns over environmental hazards led to the 1986 Emergency Planning and Community Right-to-Know Act, and the EPA's Toxic Release Inventory Program (TRI)¹ that collects information on environmental hazards in communities across the country (EPA, 2019). Executive Order 12898 was also a response to these concerns, but was more specifically focused on environmental justice. Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, signed in 1994 by President Bill Clinton, mandated federal agencies to specifically consider environmental justice as a part of their mission and to take steps to protect minority and low-income communities.

While the EJM seeks, in part, to eliminate the unequal burden of hazards placed on minority and low-income communities through environmental cleanups, these efforts may be compromised by the phenomenon of environmental gentrification. Environmental gentrification is the process by which improvements in environmental quality, including, but not limited to “cleanup[s] and [the] reuse of undesirable land uses make a neighborhood more attractive and drive up real estate prices” (Curran and Hamilton, 2012; Kern, 2014). Environmental, green, or ecological gentrification, more specifically, happens when an improvement in local environmental amenities—such as, large green development projects (LGDP), the cleanup of a locally undesirable land use (LULU)², or increases in sustainability capital (McClintock, 2018)³—either cause or exacerbate gentrification (Rigolon & Németh, 2018; Gould & Lewis, 2017). In this study, gentrification is defined by the transformation of central city working-class

¹ It also led to the Risk Screening Environmental Indicators (RSEI) model to rank the toxicity of the TRI chemicals. This is further elaborated on in the data section.

² LULU's can include industrial sites, crematoriums, or any other land use that is undesirable within a given geographic context. LULU's are also considered “Not in My Backyard” (NIMBY) issues.

³ “Sustainability capital” is the agglomeration of the cultural and social capital surrounding sustainability (McClintock, 2018). A specific example would be urban farms. Their presence in a community can create a certain aesthetic and/or perceived culture of sustainability, which in turn can be marketed by cities or communities.

neighborhoods or vacant lots to meet (upper) middle-class residential and commercial tastes (Smith, 1982; Lees et al., 2008; Zuk et al., 2017). For the sake of this paper, gentrification is made distinct from the concept of redevelopment in that gentrification is not driven by “incumbent upgrading”⁴ (Clay, 1979). In the case of environmental gentrification, these improvements in environmental quality lead to increased demand and “upgrades” (Hwang, 2019) in the socioeconomic characteristics of a community frequently caused by the out-migration of historical residents and the in-migration of new, wealthier residents (Bryson, 2012; Gould & Lewis, 2017; Maantay & Maroko, 2018). These historical residents may not only find themselves priced out of their neighborhoods, but may find themselves moving to neighborhoods with lower environmental quality than their original neighborhood.

Environmental improvements can range from the addition of a new park, to the reduction in air pollution, or to the revitalization and redevelopment of a Superfund site (Gould & Lewis, 2017; Gamper-Rabindran & Timmins, 2011; Immergluck & Balan, 2018).⁵ The motivations for these different types of environmental improvements, as well as the agents, organizations, and processes involved in making these decisions, can have critical impacts on its distributional effects (Rigolon & Németh, 2018). Ultimately, environmental gentrification is an environmental justice issue since the displacement of residents from environmental improvements is discriminatory, at least, on the basis of class. However, given how tied class and race are in the American political and economic tapestry, environmental gentrification is not only an issue of environmental justice broadly, but also environmental racism (Brahinsky et al., 2014). This is

⁴ Incumbent upgrading is where neighborhood upgrades and improvements in conditions are driven by the residents who live there.

⁵ “Superfund” is an informal name for the Comprehensive Environmental Response, Compensation, and Liability Act. It specifically grants the EPA the ability to clean up contaminated areas and/or to force responsible parties to clean up contaminated areas (EPA). Superfund sites typically pose considerable threats to public and/or environmental health, giving them a reputation for being especially dangerous.

even more troublesome if the environmental improvements, such as the cleanup of hazards, were explicitly done for the benefit of the now displaced local residents.

While there is body of literature on gentrification more broadly, there has been notably less work done specifically exploring the role of public investment in spurring gentrification (Zuk et al., 2017). Research on environmental gentrification is growing, especially as policies surrounding sustainability and green developments are becoming increasingly common (Gunder, 2006; Immergluck & Balan, 2017). While environmental gentrification has grown into its own specific area of study, it relies on the preexisting work in gentrification, environmental migration⁶ and residential sorting. Moreover, even when not explicitly the focus of the research, political economists and urban planners who have focused on the growing trends in sustainable development have noted the phenomenon, if only briefly (Agyeman & Evans, 2003; Gunder, 2006). The understanding that changes in land use—or decision making more broadly—produce both winners and losers is not new (Schmid, 2004), and the politics of sustainability and environmentalism are rife with this reality (Checker, 2011). However, it is within the explicit investigation of the processes enabling the discrepancies in benefits from environmental improvements, as well as the estimation of their effects, where the literature on environmental gentrification continues the conversation.

While fundamentally interdisciplinary, environmental gentrification has tended to be investigated in urban geography and planning, sociology, and economics—with these different disciplines offering differences in epistemology and methodology. The literature on environmental gentrification does span both quantitative and qualitative, however, a major portion of the existing work primarily utilizes a qualitative lens. Both qualitative and quantitative work has largely analyzed specific case studies of major LGDP or land reuses (Gould & Lewis,

⁶ This is not to suggest that environmental gentrification builds upon the commonly used techniques or methods of this established discipline, but rather that they share similar theoretical underpinnings.

2017; Rigolon & Németh, 2018). Green development projects of focus have included the Atlanta Beltway project (Immergluck and Balan, 2017), Gowanus Canal in Brooklyn, (Miller, 2016; Gould & Lewis, 2017), New York's High Line, and Chicago's 606 Trail (Rigolon & Németh, 2018). By focusing on specific environmental improvements, these studies have been able to identify more direct effects of these developments on the surrounding neighborhoods. The findings from these case studies have provided interesting and nuanced observations for multiple aspects of what an environmentally initiated gentrification may look like. Decreased housing affordability, increased rents, and local resentment⁷ have all been found as byproducts of LGDPs⁸ (Miller, 2016; Immergluck and Balan, 2017; Gould & Lewis, 2017; Rigolon & Németh, 2018). It has also been demonstrated that these developments have changed community demographics, for example, with the reduction of the share black and the increase in the share white (Gould & Lewis, 2017).

There are also a number of studies that have investigated broader trends in the relationship between environmental improvements and household sorting.⁹ These studies, rather than focusing on a single development, tend to focus more generally on pollution or exposure to environmental hazards. These papers have relied heavily on the EPA's Toxic Release Inventory and Superfund programs for information on point source pollution and the proximity of households to environmental hazards. The two different sets of data, while both providing evidence of exposure to pollution, differ in that Superfund sites tend to represent more significant threats to human and/or environmental health. Regardless of the data, however, many of these papers seek to understand very similar dynamics. These papers tend also to be more

⁷ The resentment of local residents can be directed towards the political process that caused the development and/or the development itself.

⁸ These effects may start to happen as soon as a LGDP is announced. The understanding that a LGDP can significantly change an area may prompt developers, investors, and speculative households to focus their attention there.

⁹ Household sorting can also be thought of as household migration.

quantitatively rigorous than those focusing on the impact of individual LGDP's, and generally work to model residential sorting through changes in demographics in response to exposure. Many of these papers focus on large geographic areas rather than one specific location. There is somewhat mixed evidence among papers of this type. Specifically, in response to environmental cleanups, some find evidence of in-migration and increases in income (Banzhaf & Walsh, 2008; Gamper-Rabindran & Timmins, 2011¹⁰). Others, find no statistically significant evidence of residential sorting in response to environmental improvements (Greenstone and Gallagher, 2008; Eckerd, 2011). The findings for how the composition of a neighborhood—not including income—changes in response to environmental improvements is even less consistent. There is some evidence of cleanups increasing the number of college-educated residents (Gamper-Rabindran & Timmins 2011), however, when it comes to racial composition there is evidence suggesting both that the share of black residents increases (Gamper-Rabindran & Timmins, 2011) and decreases (Crowder & Downey, 2010; Essoka, 2010) following a cleanup. It is important to note that many papers exploring the effects of general pollution exposure do not test for composition effects, especially racial composition effects. The effect on racial composition, however, is extremely important given the history of environmental racism and injustice. Evidence from LGDP case studies on racial composition suggest that environmental improvements can cause displacement and/or negative unintended consequences for minority groups—this result may be expected to translate to environmental cleanups as well (Gould & Lewis, 2017).¹¹ Yet, the racial composition effect has been under analyzed in this regard, leaving an unclear expectation based on the preexisting literature.

¹⁰ Gamper-Rabindran & Timmins (2011) follows closely to Banzhaf & Walsh (2008), however, they use Superfund sites instead of Toxic Release Inventory data.

¹¹ It is also worth noting that the literature documenting gentrification has also noted racialized effects and displacement (Kirkland, 2008; Lees, 2016). Although this has not necessarily been in the context of gentrification spurred by investments in public goods.

Given current trends in urban sustainable development (Checker, 2011; Immergluck and Balan, 2017) it seems increasingly prudent to research the effects of environmental improvements on not only cities as a whole, but for those who live in the very communities in which they take place. While there is some mixed evidence on the effect of environmental improvements on communities from different sources and in different locations, there is enough evidence to warrant further investigation. This paper addresses a weaker area of the literature, in focusing heavily on the racial composition effect from environmental improvements. This is even more unique given some traditional avoidance in economics research with regards to racial inequalities. Further, while quantitative in approach, the specific focus on Allegheny County as a case study offers a more targeted approach than some other similar papers. While potentially lacking generalizability, the case study can bring region-specific insights that would be overlooked in a more geographically widespread study. Although this study relies on secondary data instead of qualitative or primary data, it can also serve as a guide for future research within the county. Understanding broad residential sorting is important, but in many ways the environmental justice concerns surrounding environmental gentrification come from the way environmental improvements affect neighborhood composition.

Pittsburgh and Allegheny County, PA

Allegheny County, Pennsylvania is currently the second most populous county in the state, with its county seat in the city of Pittsburgh. Situated around three major rivers, the Allegheny, Monongahela, and the Ohio, Allegheny County, and specifically Pittsburgh became a major port for commerce. This along with the Allegheny Mountains' deposits of iron and coal made the area a major manufacturing hub for the iron and steel industries. While these characteristics helped support economic activity and development in the early stages of

industrialization, the pollution from coal-powered manufacturing led to drastic reductions in air quality (Longhurst, 2007). Further, the actual geography of the region helped to make air pollution worse by trapping it (Longhurst, 2007). Not only was the air polluted, but local streams were often exposed to slag and waste as by-products to the industrial boom (Goldstein et al, 2003).

For most of Pittsburgh's modern history, its identity has been synonymous with steel, iron, and smog (Davidson, 1979). The "Smoky City" was infamous for frequently needing to use street lights in the middle of the day due to the dense smoke and blackened skies (Ali & Zhao, 2008). Even before more recent considerations of environmental quality and health, residents and visitors to the city in as early as 1804 recognized the particularly intense levels of smoke within the city as dangerous (Davidson, 1979). However, due to the increased demand caused by the industrial revolution, as well as the Civil War, little was done for the abatement of smoke until the early to mid-1900's (Davidson, 1979). Even then, the area's air quality was frequently reported as some of the worst in the country. However, in the early 1980's, Pittsburgh saw the rapid crash of its steel industry (Toland, 2012; Streitfeld, 2009). This resulted in high unemployment rates, and ultimately the closure of local steel mills and factories.

With the rise of the US environmental movement, the federal government began to create stricter stipulations with regard to air pollution, as well as improved reporting and abatement technologies. Starting in the mid-1900's, concern over environmental pollution began to surge (Longhurst, 2007). Environmentalism was a prominent part of the policy agenda, and the country saw the passage of significant acts such as the Clean Air Act which was signed in 1970 (EPA, 2019). The Clean Air Act established ambient air quality standards and required states to actively create and follow strategies to combat emissions. It also called for factories, power plants, and point source polluters to adopt better and cleaner technology. The Clean Water Act of 1972 similarly helped to deal with emissions discharged into local waters (EPA, 2019). While these

acts have done much to regulate and control the environmental hazards released into the air and water sources, Pittsburgh has been among a number of offenders who regularly fail to meet federal air quality standards (Mericle, 2019). The Allegheny County Health Department (ACHD) which has the duty to enforce laws dealing with environmental health, has reportedly underenforced the standards created by the Clean Air Act with regards to the county's biggest polluters (Dutzik & Barber, 2019).

Today, the city remains heavily polluted relative to other US cities, and has repeatedly scored poorly on the American Lung Association's annual air quality report card (Marusic, 2019; Goldstein et al., 2003). In 2019, the Pittsburgh MSA¹² ranked 10th in short-term particulate pollution and ranked 7th in annual particulate pollution (American Lung Association, 2019). It also ranked 17th in the number of census tracts with greater than one in ten thousand risks of air-pollution related cancer in 2005 (EPA, 2011; R.H. White Consultants, LLC, 2013). While, Pittsburgh no longer has any active mills within the city limits (Popular Pittsburgh, 2015), the area still contains heavy polluters, including the Mon Valley Works, Shenango Coke Works, and Allegheny County's other "Toxic Ten". These ten facilities emitted 1.4 million pounds of toxic materials in 2013 (Inglis & Garber, 2015). While in the decades prior, the ACHD may have taken a less strict approach, they have recently taken stricter actions against these particularly egregious polluters (Dutzik & Barber, 2019).

Nonetheless, Pittsburgh is seen at being at the forefront of urban regeneration. Local organizations and policymakers have worked to reimagine the city. The city, once known for manufacturing and industry, is now increasingly becoming a hub for technology, health care, and financial services much like other successful postindustrial, Rust Belt cities (Popular Pittsburgh, 2015). Due to the decline of the steel industry, many of the local industrial facilities have shut

¹² The Pittsburgh, PA, New Castle, OH, and Weirton, WV area shares this ranking.

down and the city has redeveloped many of these brownfield sites into parks, entertainment hubs, and apartments (Palko, 2015). Although the area has its issues with air quality, the topic of sustainability is becoming an increasingly common objective in the city and region's plans for redevelopment. It is for this reason, that this region was chosen to be the focus of this study. While the area is still going through the process of environmental cleanups and developments, the area's historical connection to industry and subsequent redevelopment make it an excellent case study for how environmental improvement can affect communities. The region is an even more interesting case study given that Pittsburgh was ranked the 8th most gentrified city from 2000 to 2013 (Richardson et al., 2019). To analyze how environmental cleanups can affect neighborhoods in postindustrial regions, this paper focuses on Allegheny County from 1990 to 2010. To date there seems to be a lack of work done on this topic in such a region, and this allows for this paper to offer insights for both racial composition effects, as well as for the effect of sustainability trends in postindustrial cities.

The following section introduces the theoretical framework, as well as the empirical strategy employed for this analysis. Tiebout sorting and the Racial Income Inequality Thesis provide for a frame to understand how household sorting is not only a function of individual preferences, but also of systematic constraints. These theories give predictions for how households will respond to environmental cleanups, and they ultimately inform the differences-in-differences approach. Along with the existing work in environmental gentrification and the realities of Allegheny County, these theories work to contextualize the main research question of this study: How has the cleanup of TRI facilities in Allegheny County, PA from 1990 to 2010 affected neighborhoods? Based on the gaps in the literature, this study focuses on the changes in neighborhood demographics including scale and income, but with specific attention to racial composition.

Chapter 3

Theory and Empirical Strategy

Theory

In order to understand how neighborhoods in Allegheny County changed from 1990-2010 due to environmental improvements, it necessary to establish a series of assumptions and understandings about the dynamics of residential sorting. The economic study of environmental gentrification has frequently been seen as an extension of Tiebout's sorting thesis (1956) to the case of environmental quality change (Banzhaf & McCormick, 2006; Eckerd, 2010; Gamper-Rabindran & Timmins, 2011) as was discussed in Banzhaf & Walsh (2008). Due to the difficulty in estimating the value of public good expenditure, caused by its non-market nature and skepticism towards stated preferences, Tiebout's theory presented a way to uncover the value households placed on local public goods. Whilst assuming full mobility, perfect information, and a sufficiently large number of communities, the theory states that households will locate into communities that match their preferences for public goods (1956).¹³ Households as "consumer-voters" are predicted to "vote with their feet" and match, along with other consumer-voters, to communities that have preferable levels of, for example, school quality, crime rates, or environmental quality (e.g. parks, air pollution). Because of the constraints on the resources that local governments can put into expenditure on public goods, they necessarily must prioritize where to best allocate funds. In this model, housing prices serve as the instrument by which

¹³ Tiebout also assumes that there are no restrictions in employment, that public services are locally decided, each community has an optimal size, and that communities at sub-optimal sizes will work to attract more residents.

consumers can indicate their demand for public goods. At equilibrium, what results is a continuum of communities differentiated by levels of public good quality. Here, those who value a particular public good the most will sort into the community with the highest level of said public good, while those who value¹⁴ the good the least will sort into the community that has the lowest level of the good. It is important to note that households, of course, face many constraints, with income being a primary one. Laws and preexisting institutions can also serve as constraints upon households' ability to sort (Crowder & Downey, 2010). None of these constraints, however, negate the main point of Tiebout's thesis, and the theoretical implications remain mostly the same.

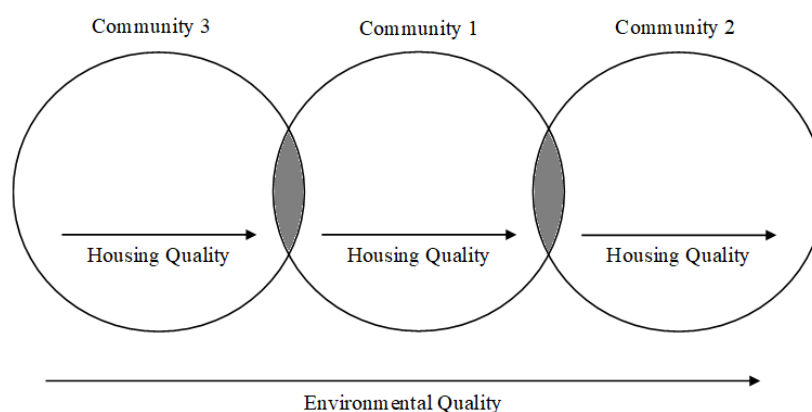


Figure 3-1: Tiebout Sorting - Setup

The extension of Tiebout sorting to the topic of environmental quality is a fairly simple task. Much like school quality, goods like open space, parks, and clean air can be evaluated as public goods that consumers can sort for. Under the aforementioned assumptions, if communities were differentiated only in terms of environmental quality and housing prices, the model would

¹⁴ Here, “value”, is not necessarily meant to be substituted for a household or individual’s moral code, or even preferences. Rather, what a household is willing to pay for a bundle of characteristics given their constraints (income).

predict that the richest households would sort to the “best” neighborhood and that the poorest households would sort into the “worst” neighborhood, assuming that environmental quality is a normal good.

Economists, Banzhaf and Walsh (2008) further elaborate on the model’s prediction when a neighborhoods environmental quality increases or decreases. Suppose there was a linear ranking of all given communities on a continuum from worst to best environmental quality. In each community, there is also an identical distribution of homes from lower to higher end. This situation is presented in Figure 3-1. Here, Community 3 has the worst environmental quality, as a community, among these three neighborhoods. At equilibrium, the expectation is that Community 2, due to its higher value of environmental quality, would overall have higher income and housing prices than Communities 1 and 3. Yet, there would be a number of households in Community 2 whose homes are at the bottom distribution of housing quality. While they would benefit from the higher environmental quality of Community 2, their housing quality is low enough to make them relatively indifferent between living at the lower end of Community 2, or the upper end of Community 1. Specifically, the difference between the value of environmental quality between the communities is just enough to offset the difference of the value of housing quality. Although households could move to Community 1 from Community 2 and consume a higher level of housing, they would experience enough of a drop in environmental quality that would make them just as well off as if they had stayed in the bottom end of housing in Community 2. Similarly, consumers who moved to Community 2 from Community 1, while they could experience a higher level of environmental quality, they would experience just enough of a reduction in housing quality to make them just as well off as if they stayed in Community 1. The prices of homes would be equal within this point of indifference. These “borderline households” are the ones who will be most affected by environmental quality changes.

If Community 1 experiences a marginal improvement in, for example, air quality, Community 1 would experience a shift towards Community 2. Initially, this would present households from Community 2 with the opportunity to relocate into homes in Community 1, where the reduction in the value of environmental quality is now less than the value of the potential improvement in housing quality. For the same initial prices of homes, the model predicts that borderline households from Community 2 will move to Community 1. An equilibrium would be eventually reached where the point of indifference between Community 1 and Community 2 would be higher than it initially was. This is shown in Figure 3-2. Now that environmental quality is more similar between the communities, the difference in housing quality must also be smaller, leading to overall higher home values¹⁵ and a higher price at the point of indifference.

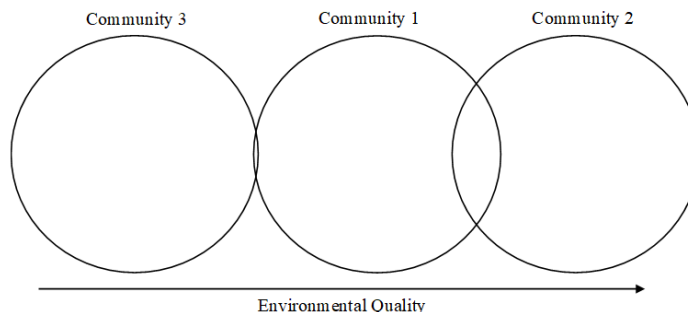


Figure 3-2: Tiebout Sorting – Environmental Improvement

Consider Community 3, which is the worst community in environmental quality among the three neighborhoods. Here, the households at the highest end of the housing quality distribution would be at the point of indifference between Community 3 and Community 1. With

¹⁵ In this model, home values will reflect households demand for a home's housing quality and the environmental quality of the given community.

the increase in environmental quality experienced by Community 1, borderline households from Community 3 would then be incentivized to relocate to Community 1. At this point, the improvement in environmental quality is greater than the reduction in housing quality, and at the same initial price, Community 1 would be preferable.

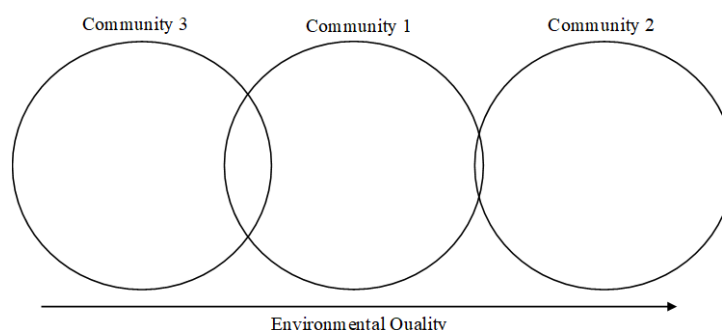


Figure 3-3: Tiebout Sorting – Environmental Degradation

Now, if Community 1 experienced a decline in environmental quality, it would become more similar to Community 3. Figure 3-3 shows this shift. Here, borderline households from Community 3 would find that the difference between environmental quality between the two communities is smaller than it initially was. While Community 3 borderline households would still be willing to relocate to Community 1, they would now find that they would need to obtain better housing quality, as compared to what they initially demanded in Community 1, to offset the loss in environmental quality. Because they no longer gain as much of an improvement in environmental quality, these households must be compensated with a smaller difference in the housing quality in order to be indifferent between these communities. The number of households at the borderline point between Community 3 and Community 1 would also increase since the communities are more similar. There would be fewer households willing to move from

Community 2 to Community 1, however. These households would now need to be compensated with a larger increase in housing quality to compensate for the larger difference in environmental quality. As depicted, only the households at the very bottom of Community 2's housing distribution would be willing to move to Community 1, and to do so, they would demand only the best housing in the neighborhood.

Applying Tiebout's model of sorting specifically to the impact of environmental change in Allegheny County, PA allows for the establishment of hypotheses regarding scale and income effects. Somewhat intuitively, it can be expected that environmental cleanups lead to communities experiencing an influx of new and wealthier households. However, in order to test these hypotheses, it is important to relax some of the initial modeling assumptions. Specifically, it is likely unreasonable to assume that communities along the continuum of environmental quality all have the same distribution of housing quality. While helpful in considering how environmental changes would affect shifts in communities, it is unlikely that a mansion would be located in a

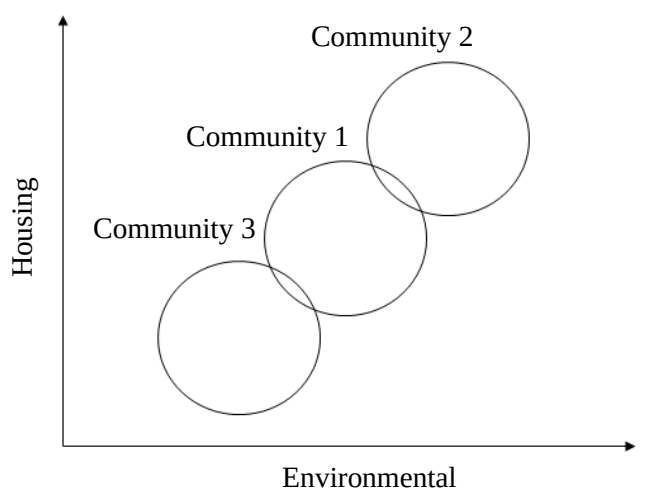


Figure 3-4: Tiebout Sorting – Housing Quality vs Environmental Quality

highly polluted community. Similarly, affordable housing developments are not likely to be in highly affluent communities.

Figure 3-4 shows a relaxing of this modeling assumption, yet, its predictions are not significantly different. Instead, it suggests that, at least in the short term, communities are likely clustered together in different groups along the continuum. In Figure 3-4, Community 3 is the community with the lowest levels of both housing quality and environmental quality. Community 2 is the community with highest levels of housing quality and environmental quality, and Community 1 is the community in the middle. If Community 3 were to experience a rapid environmental cleanup that brought it to the environmental quality levels of Community 2 (Figure 3-5), it is unlikely that Community 3 would have the housing quality or other amenities that the majority of households from Community 2 would be seeking. Unlike Community 1 and Community 2, households from Community 2 were not indifferent between their current

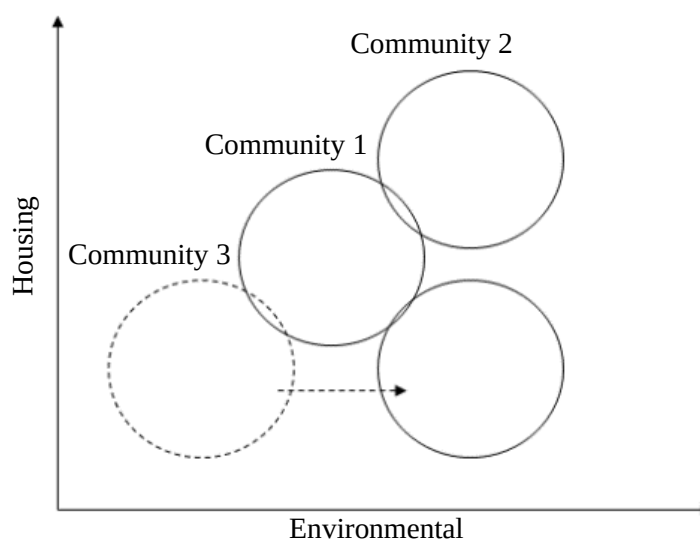


Figure 3-5: Tiebout Sorting – Housing Quality vs Environmental Quality (Improvement)

residences and those in Community 3. Not only would households from Community 2 have suffered losses in environmental quality from having moved to Community 3 before its cleanup,

but these households would have also suffered losses in housing quality. Because of the relatively higher income and/or preferences of households in Community 2, they would continue to prefer Community 2 regardless of how clean Community 3 becomes. This means that households likely migrate in and out of communities that provide them with relatively comparable bundles of amenities and goods.¹⁶ This does not mean that Community 3 will never be attractive to households from Community 2, but it is a less likely outcome in the short-term, at least until the improvement of some other amenity in Community 3 relative to Community 2—or a massive reconstruction of housing.¹⁷

Scale Effect and Income Effect

Tiebout's sorting model presents a way to predict how households will react to changes in environmental quality, however, it does not have a clear prediction on whether or not environmental gentrification will result from environmental improvements. Rather, the model offers insights on environmentally motivated migration. The model specifically offers the clearest predictions with regards to scale (Banzhaf & Walsh, 2008). Scale effects are the effects to population and population density. Using the previous examples, it seems clear that, with an environmental improvement, Community 1 will attract households from the lower end of Community 2 and experience an increase in population and population density relative to the other communities. With an environmental degradation, fewer households from Community 2 would be willing to move to Community 1, while there would be more households willing to move from Community 3 to Community 1. The households within Community 1 that were

¹⁶ This can include the speculation that a community may, in time, reach a certain level of housing or environmental quality.

¹⁷ Like Figures 3-4 and 3-5, it is possible to imagine a 3-dimensional space with a third amenity. The third amenity, specifically the difference in this amenity, could make it more likely for Community 2 residents to consider Community 3.

originally indifferent between staying and leaving to go to Community 2, would also no longer want to stay in Community 1. This leads to an expected decline in total population and population density.

The income effect is slightly less clear. Since the households from Community 2, are expected on average to be richer than those of Community 1, income in Community 1 may be expected to increase after an environmental improvement. However, since Community 1 is also gaining households from Community 3, who on average are expected to have lower incomes, the result is not immediately clear. It ultimately comes down to the level of increase in environmental quality, and the populations of Community 3 and Community 2. If the increase in environmental quality is sufficiently large, then a considerable portion of households from Community 2 could relocate to Community 1 and experience a sizeable increase in housing quality for a relatively

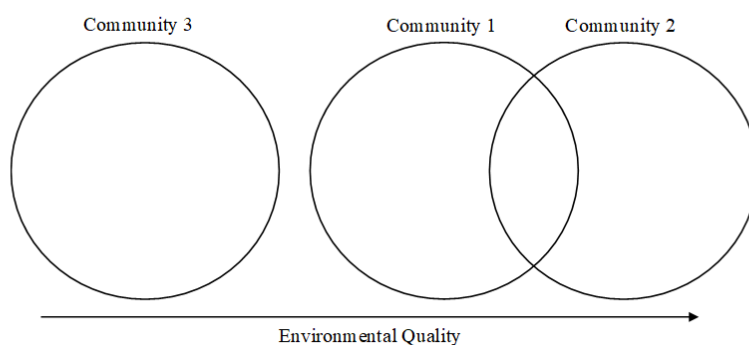


Figure 3-6: Tiebout Sorting – Environmental Improvement (Large)

small decrease in environmental quality. With this sufficiently large environmental quality increase, it is also possible that only the very richest households from Community 3 could move to Community 1. If large enough, the difference in environmental quality could be so large as to supersede the difference in housing quality for most households. This means that only those who have homes of the highest housing quality could afford to move to Community 1. Theoretically,

all households from Community 3 could be priced out. See Figure 3-6. The result would find a positive effect on income in Community 1. Opposingly, if the improvement in environmental quality was sufficiently small, only the households at the very bottom of the housing distribution in Community 2 would be willing to move to Community 1. However, because of the relatively small increase in the difference in environmental quality between the two communities, more households from Community 3 could be expected to sort to Community 1. This may result in a very small, or negligible change in income for Community 1. For a decrease in environmental quality, the expectation is just the opposite. Since these communities differ only in regard to environmental quality, as a community becomes dirtier, the richer residents of the community are going to be motivated to leave and poorer households are going to be willing to enter. This is not to suggest that poor households prefer dirtier communities, but to instead suggest that higher pollution tends to lead to cheaper housing. In this specific scenario, as Community 1 becomes dirtier—and has less demand for its housing—households from Community 3 have increased access to the still better Community 1.

Composition Effect

Even less explicit, is the resulting composition effects (Banzhaf & Walsh, 2006). The composition effect is the effect of environmental changes on the makeup of a neighborhood. This can include changes in age breakdown, shares of different racial groups, or education levels. While age and education are difficult to clearly predict with the model, the effect of environmental changes on racial composition is somewhat clearer by updating Tiebout's thesis with the Racial Income-Inequality Thesis (Oakes et al, 1996; Downey, 2005; Crowder & Downey, 2010). According to this theory, "racial differences in exposure and proximity to environmental hazards largely reflect group differences in socioeconomic resources" whereby

“racial differences in the likelihood of moving into and out of environmentally hazardous neighborhoods emerge largely as a function of group differences in socioeconomic resources” (Crowder & Downey, 2010). Environmental justice research has long found that race is one of the strongest predictors of exposure to environmental hazards (United Church of Christ, 1987). Given evidence that suggest minority populations, specifically blacks, are positively associated with exposure to environmental pollution, as well as the historical relationships between race and class, Tiebout’s model can have reasonable predictions of racial composition effects. Here, with a decrease in environmental quality it may also be expected to see an increase in the proportion of minority residents due to cheaper housing. Conversely, an improvement in environmental quality may make a neighborhood more attractive to wealthier—and potentially white—households, making housing relatively more expensive. This may lead to the displacement of minority residents.

Data

The mechanics of constructing the dataset follow from Banzhaf and Walsh’s paper (2008). To do this, data were collected from the 1990 and 2000 decennial Census surveys as well as the 2006-2010 (5-year estimates) American Community Survey all at the block group level. Like many other environmental justice studies, this study relied on the EPA’s Toxic Release Inventory (TRI) and Risk-Screening Environmental Indicators (RSEI) model to provide data about point source pollution. While there is an ever-growing body of literature on the topic of gentrification, the definition is generally a function of the researcher’s discipline and data (Maantay & Maroko, 2018). Economists studying gentrification typically think about the process in terms of its common broad demographic and economic effects, including significant changes in income, rent, and home values (Banzhaf & Walsh, 2006; Eckerd 2011; Greenstone & Gallagher,

2008). This quantitative approach may differ from how those using qualitative data both work with and define gentrification. Qualitative researchers may be more likely to consider gentrification as a change in neighborhood identity and culture, or in the quality of housing and amenities (Miller, 2016; Rigolon & Németh, 2018; Maantay & Maroko, 2018). In other words, gentrification, at least initially, may not present itself as a direct change in income, rent, or some other commonly used metric for gentrification. Instead, it can take the form of a change in aesthetic caused by an in-migration of different demographic groups looking for cheap housing (Ley, 1986, 2003). For the sake of this study, the data will consist of demographic and economic measures of gentrification.

Spatial Scale of Analysis

Obtaining the correct scale of analysis is vital to studying migratory trends and the localized effects that define gentrification. Similar studies have used a number of different levels of analysis, including block groups, census tracts, and locally defined neighborhoods (Banzhaf & Walsh, 2008; Eckerd, 2011). Due to the potential issues raised by these other methods, including inconsistent geographies over time, and endogeneity and bias due to gerrymandering, this study constructs a new geographical unit as defined by quarter square mile area¹⁸ hexagons. This differs from Banzhaf and Walsh's half-mile diameter circles (2008). Hexagons were chosen for complete coverage of the regions, which circles would not provide. The quarter square mile area was chosen to take advantage of a more granular analysis. Utilizing ArcGIS, a hexagon tessellation was generated to cover the entirety of Allegheny County.¹⁹ Given the nature of gentrification, and the relatively localized effect a LULU might have, these hexagon communities also provide a

¹⁸ The hexagons, more specifically, have an approximate area of .2465 mi².

¹⁹ Due to the choice of hexagons, their size, and the shape of Allegheny County, communities on the border of the County include information from block groups adjacent but not directly in Allegheny County.

way of analyzing lower-level changes than might not be picked up from an analysis using counties. Further, by using this geographical unit, this study is able to maintain a consistent scale of analysis over time that does not suffer the potential endogeneity issues of tracts or locally defined neighborhoods²⁰.

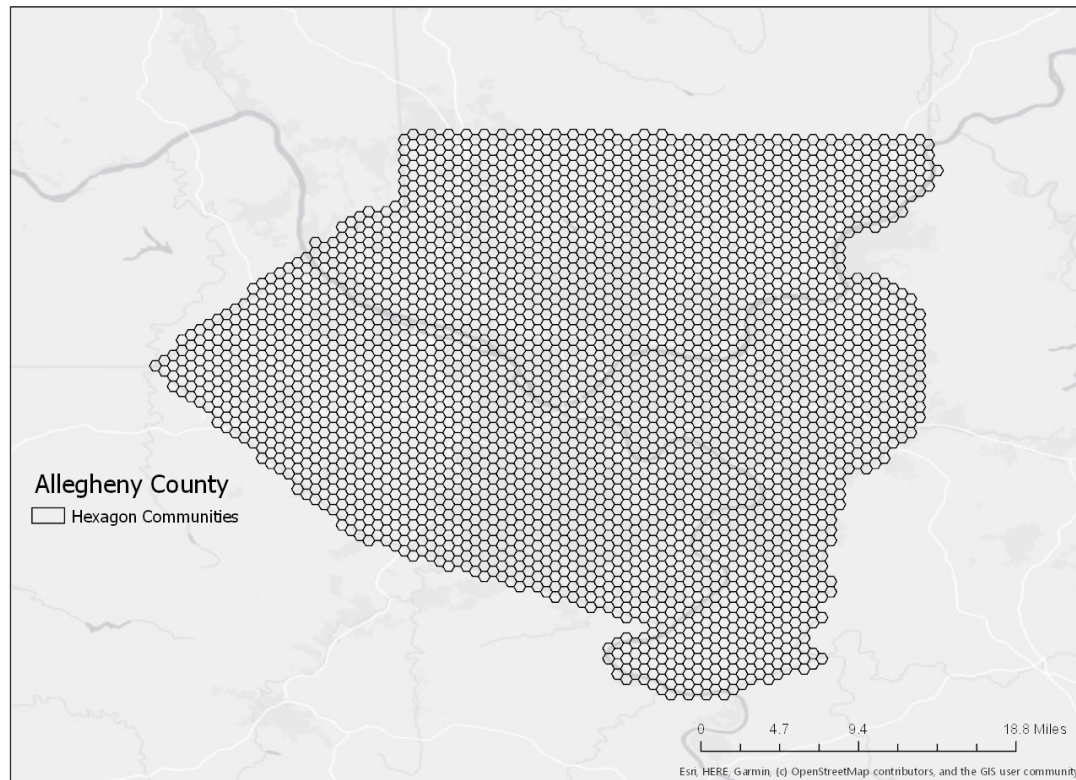


Figure 3-7: Map of hexagon communities

²⁰ Neighborhood definitions change over time and can boundaries can be hard to define. The boundaries can also be at such a size as to limit the total number observations to a very low number—it may also lower granularity.

Census

The tessellation was later merged with the geolocated Census block groups²¹, where both the area of the community made up of each block group and the area of the block group that was located in a particular community were calculated. Table 3-1 shows the summary statistics for baseline demographic variables²². Using the percentage of the block group's area that was located in a hexagon, or community, the population data were then distributed to each community respectively²³. For example, take a block group with 2,000 people, overlapped by two hexagon communities— where 80% of the block group is in community one and 20% is in community two. Community one would have a total population of 1,600, while community two would have a population of 400. Due to the difficulty of aggregating median data, a spatially weighted average of medians was calculated for median income, rent, home value, and year housing structures were built. The spatial weight used was the percentage of the hexagon community's area that was made up by a particular block group. Due to missing observations, or block groups with zero population, some block groups and hexagons were omitted.

²¹ The 1990 and 2000 Census data were geocoded to 2000's block groups, while the 2010 ACS was geocoded to 2010 block groups.

²² These baseline demographic variables are the one-time period lagged demographic variables used in the estimation model. This is further discussed in the section on estimation.

²³ Block groups with missing data, or with total population, median income, median rent, median year built, or median home value equal to zero were dropped from the analysis.

Table 3-1: Baseline Summary Statistics

	mean	sd	min	p25	p50	p75	max
Total Population	352	529	13	56	141	389	4,240
Population Density (per sq. mile)	1,459	2,172	54	228	577	1,603	17,147
Percent white	93.5%	12.7%	1.5%	95.0%	96.9%	98.3%	100.0%
Percent black	4.6%	12.3%	0.0%	0.5%	1.4%	2.8%	97.0%
Percent Native American	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.7%
Percent Asian	0.8%	1.3%	0.0%	0.2%	0.4%	1.0%	15.9%
Percent Latino	0.6%	0.4%	0.0%	0.3%	0.5%	0.7%	3.3%
Median Income	59,392	22,266	14,193	46,602	54,342	67,360	194,088
Median Home Value	124,092	89,706	27,012	84,376	106,817	132,434	836,790
Median Rent	735	237	244	582	678	835	2,535
Median Year Structure Built	1,959	11	1,933	1,953	1,958	1,966	1,991
Percent with less than high school diploma	17.0%	8.2%	0.6%	10.8%	15.9%	22.5%	51.1%
Percent with at least a bachelor's degree	22.4%	14.3%	1.6%	11.4%	17.5%	31.4%	79.1%
Percent employed in managerial positions	31.3%	11.8%	3.3%	23.0%	28.9%	38.3%	78.7%
Percent employed in production positions	18.1%	9.2%	0.0%	11.0%	16.6%	24.3%	44.6%
Percent unemployed	5.2%	3.4%	0.0%	3.0%	4.7%	6.4%	53.7%
Percent single- parent (male)	3.1%	1.1%	0.5%	2.3%	3.0%	3.8%	7.7%
Percent single- parent (female)	9.8%	5.0%	2.6%	6.9%	8.8%	11.3%	76.0%
Occupancy Rate	94.1%	3.8%	57.2%	92.7%	95.0%	96.4%	100.0%
Vacancy Rate	5.9%	3.8%	0.0%	3.6%	5.0%	7.3%	42.8%
Percent renter- occupied	22.4%	14.5%	1.4%	12.1%	18.1%	29.3%	91.5%

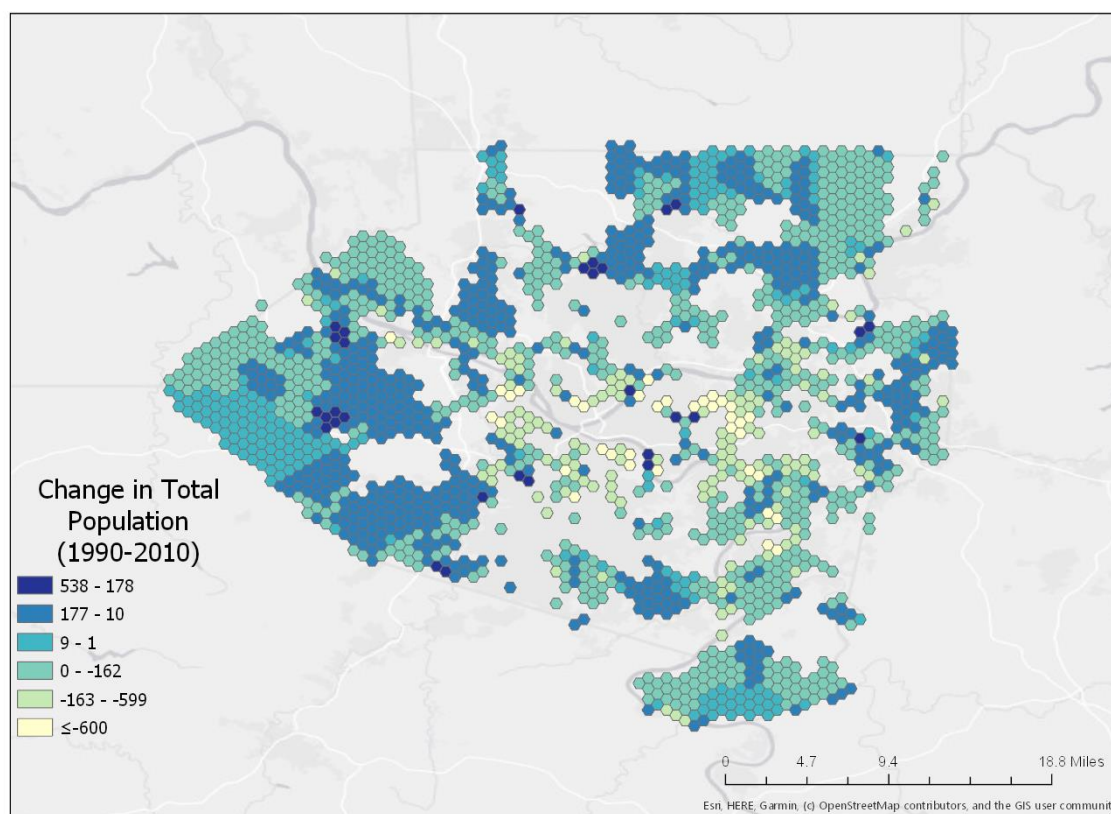


Figure 3-8: Change in Total Population (1990-2010)

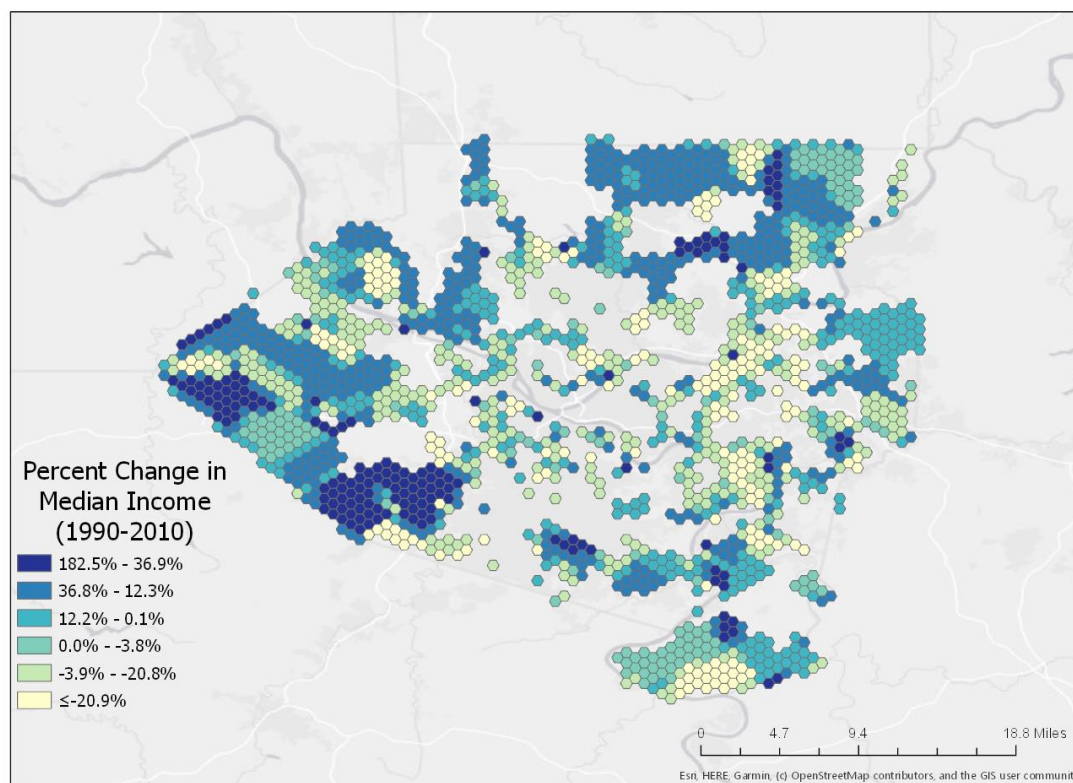


Figure 3-9: Percent Change in Median Income (1990-2010)

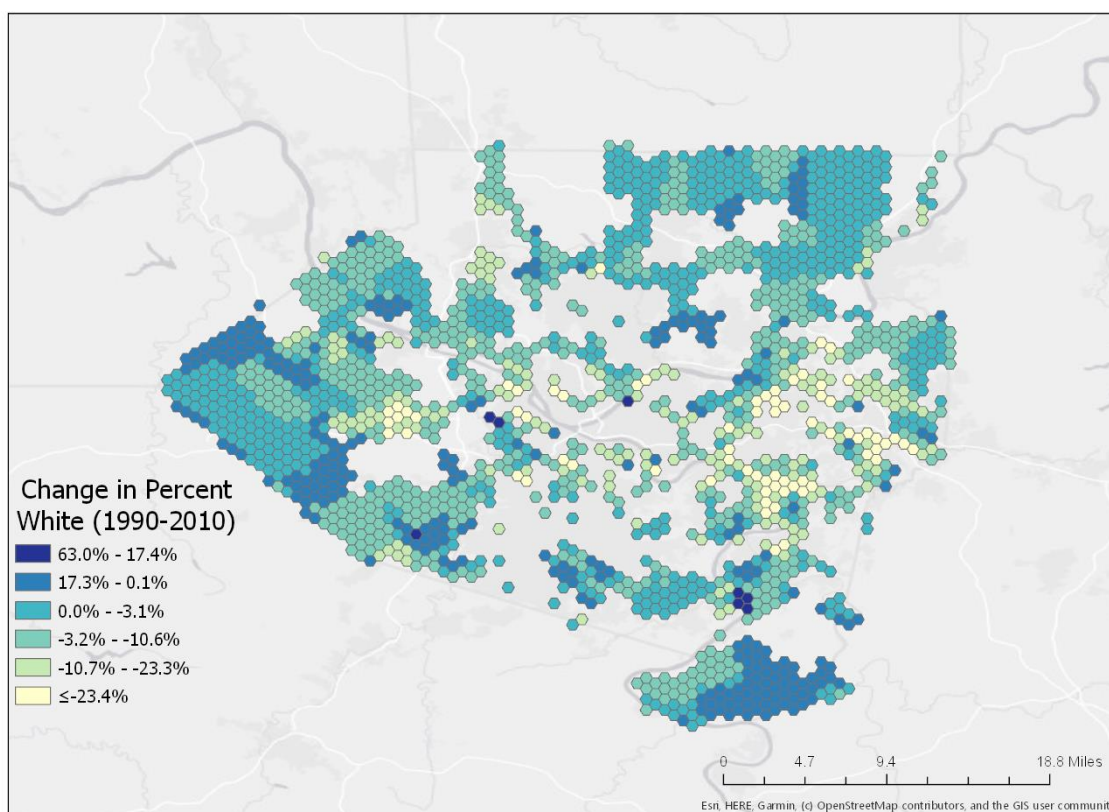


Figure 3-10: Change in Percent White (1990-2010)

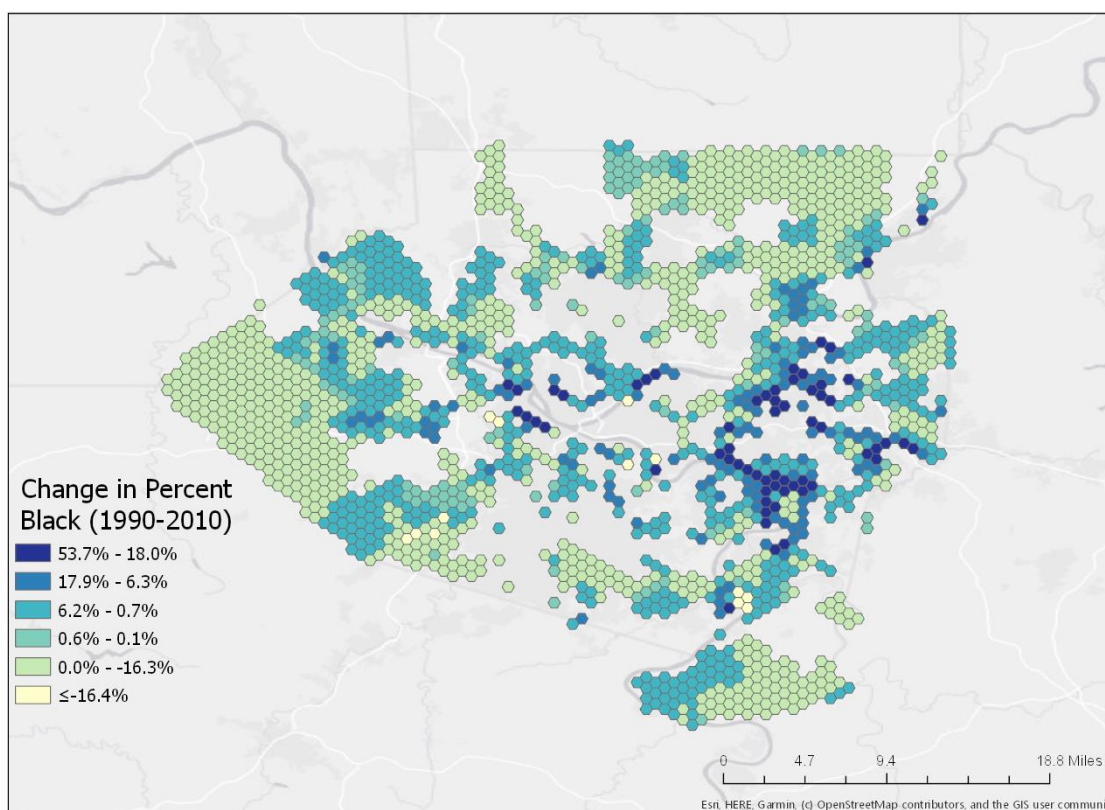


Figure 3-11: Change in Percent Black (1990-2010)

Toxic Release Inventory

The EPA's Toxic Release Inventory (TRI) is a program that tracks the pollution of certain chemicals released from industrial activities in the United States, and has done so since 1987 (EPA, 2019). The program was established in response to the Emergency Planning and Community Right-to-Know-Act (EPCRA), and it requires facilities that release one of the 628 chemical or chemical categories²⁴ covered by the program to submit data annually (EPA, 2019).

²⁴ The chemical and chemical categories reported by the TRI program have changed from 1987 to 2010, however, most have remained the same.

The chemicals under consideration by the TRI program are those that have been found to be carcinogenic, or have been deemed to be considerably hazardous to human and/or the environment's health (EPA, 2019). Polluting facilities are required to submit data regarding every TRI tracked chemical, and its release into air, water, or in land disposals (EPA, 2019). The EPA's Risk-Screening Environmental Indicators (RSEI) model is designed to assign hazard and risk weights to the chemicals under the jurisdiction of the TRI program. The hazard-weighted measure of pollution is calculated by taking the three-year lagged average of TRI data and multiplying it by RSEI's assigned toxicity weight for each chemical given its medium of release.²⁵ These products are then summed across all the chemicals at a given TRI facility. Using this model, it is possible to understand, not only in pounds how much a given area is exposed, but also how hazardous the exposure is.

Given the data's public nature²⁶ and the level at which it is reported, the TRI program allows households and communities to regularly track their exposure and health risks from local pollutants. To the extent that households consider the toxicity of their local environment, the hazard weighting system derived from the RSEI model can help capture the effect of more hazardous chemicals on household sorting. This is particularly advantageous as it presents data that individual households could reasonably adapt and respond to. The data have significant coverage and overall quality, as the EPA has legal authority to require facilities to report their chemical releases. TRI data have also frequently been used by environmental justice studies, further validating it as a reliable dataset.

²⁵ Chemicals often are released through multiple mediums, and are assigned different toxicities depending on their medium of release (i.e. air, ground water, surface water.).

²⁶ The EPA provides several user-friendly tools and resources for communities to understand both their local exposure and hazard. See <https://www.epa.gov/toxics-release-inventory-tri-program/tri-data-and-tools>.

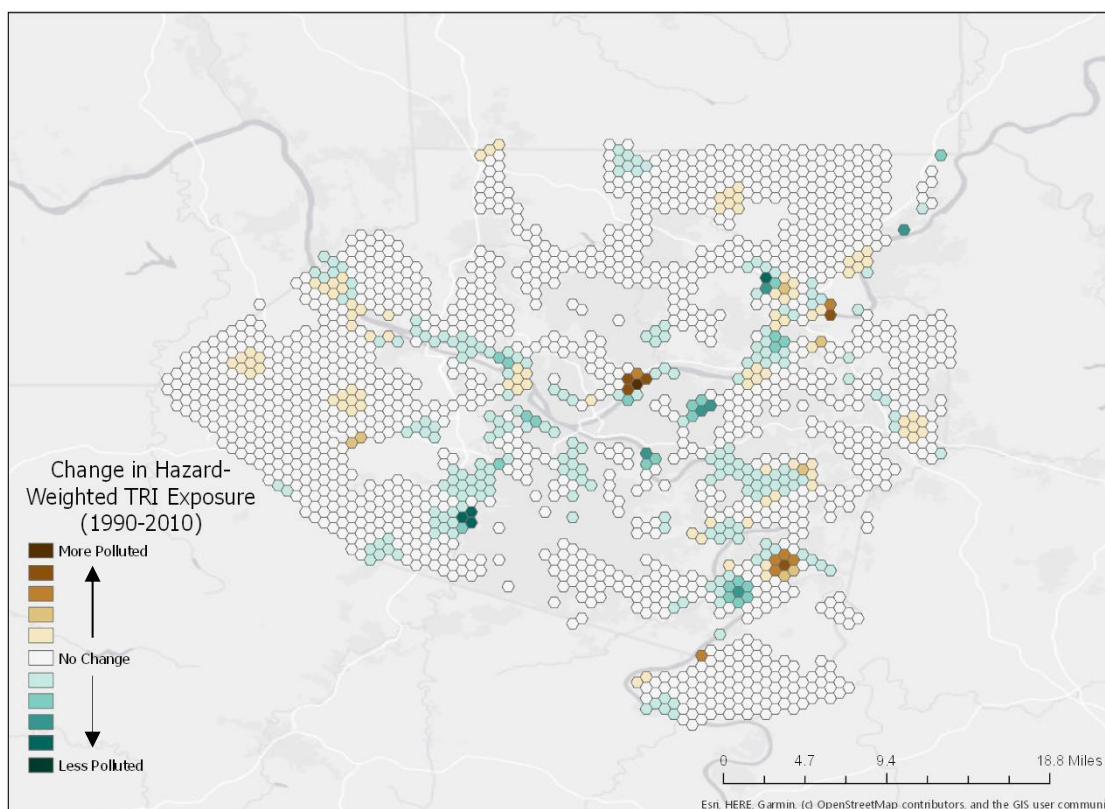


Figure 3-12: Change in TRI Exposure (1990-2010)²⁷

In order to use these data to measure community exposure, half-mile diameter buffers were created around each TRI facilities. The total, hazard-weighted pollution was then distributed to each community that intersected with the buffer based on how much of the buffer was in each individual hexagon. This captures the reality that hazardous facilities and pollution can affect more than the community they are directly located in. Unfortunately, it would be difficult to fully

²⁷ The darker brown areas represent areas that gained the most additional TRI exposure, while the dark green areas are those that experienced the greatest decrease in TRI exposure. White areas are those that experienced no change in TRI exposure. The gaps, or missing areas, are those that were dropped from the analysis.

determine the true area of impact for each facility given the specific chemical, level of output, and medium of release. This was why a half-mile diameter was selected²⁸. This is likely an underestimation of a facility's true effect, and as such, it will ultimately lead to conservative estimates (Banzhaf and Walsh 2008). Even if the true area of effect is smaller, the estimated results would tend to be biased towards zero. In this case, pollution would then be attributed to areas that weren't actually affected, reducing the differential effect for changes in exposure. If the true area of effect was bigger, then there are hexagon communities used as controls even though they are actually being treated. This would cause an underestimation of the differential effect. Figure 3-12 shows the change in TRI exposure across Allegheny County from 1990 to 2010.

Table 3-2: Pairwise Correlations

	Total Hazard	Total Population	Population Density	Median Income	Percent white	Percent black
Total Hazard	1					
Total Population	0.0431***	1				
Population Density	0.0492***	0.9978***	1			
Median Income	-0.0563***	-0.2469***	-0.2557***	1		
Percent white	-0.0281**	-0.4219***	-0.4222***	0.2386***	1	
Percent black	0.0347**	0.4004***	0.4009***	-0.2830***	-0.9726***	1

* P<.1, ** p<.05, *** p<.01

Table 3-2 shows the correlations between the hazard-weighted TRI exposure and a number of variables representing the scale, income, and composition effects. As can be seen, TRI exposure is significantly correlated with all of these variables, and these correlations generally have the expected signs. Here total population and population density are positively correlated with TRI exposure. Since these are simple correlations, it is likely because of the prevalence of pollution in the city. Median income is negatively correlated with exposure, which is as expected.

²⁸ This is the same scale that Banzhaf and Walsh used (2008).

Percent white is negatively correlated with TRI exposure, while percent black is positively correlated with exposure. Given the Racial Income-Inequality Thesis, as well as the history of environmental injustice, this is also the expected result.

Estimation

Similar to Banzhaf and Walsh (2008), this study uses a differences-in-differences approach to estimate the treatments effects of baseline exposure, new exposure, and TRI facility exits. Baseline (BL) exposure is the exposure a community had in the previous time period. New exposure is when a community that previously was not exposed (i.e. did not have baseline exposure) gained exposure. Exits are when a community had baseline exposure, but is no longer exposed. Here, exposure is defined as the presence of at least one actively polluting TRI facility.²⁹ TRI facility exits are treated as cleanups for the sake of this analysis, although technically the two are not the same. Instead, a TRI facility exit simply indicates that the facility is no longer releasing any of the TRI listed chemicals. However, it is possible that the chemicals that were previously released into the ground or surface water, or other hazards still exist at the site. Such sites are known as brownfields. Ultimately, this should bias the results towards zero, as true cleanups would likely result in larger effects and higher increases in environmental quality. This study estimates these treatment effects to understand how households in Allegheny County, PA sort according to environmental changes between 1990 and 2010. Specifically, with consideration to the scale, income, and composition effects.

Equation 1

$$\Delta y_{it} = \delta_0 + \alpha^{BL} BL_{it} + \alpha^{New} New_{it} + \alpha^{Exit} Exit_{it} + \beta^{BL\ Hazard} Hazard_{it-1} + \beta^{+\Delta} \Delta Hazard > 0_{it} \\ + \beta^{-\Delta} \Delta Hazard < 0_i + \delta^D D_{it-1} + \delta^{FE} FE_{it} + \varepsilon_{it}$$

²⁹ Any hexagon that intersects a half-mile buffer around a TRI facility is exposed.

Equation 1 describes the initial model used for this study, and it is nearly identical to what was done by Banzhaf and Walsh (2008). The change in some y_{it} is regressed on a series of discrete indicator variables, continuous measures of exposure to pollution, year lagged demographic variables³¹, their squared values, and hexagon community-level i and year (decade)

Table 3-3: Change in Demographic Variables

1990-2000	mean	sd	min	p25	p50	p75	max
Total Population ³⁰	-20	108	-1229	-31	-2	14	421
%Δ	2.6%	35.8%	-82.6%	-11.6%	-2.7%	11.8%	392.5%
Population Density (per sq. mile)	-81	440	-4712	-138	-9	57	1692
%Δ	2.7%	35.9%	-82.7%	-11.2%	-2.4%	11.8%	374.6%
Median Income	4159	10932	-35363	-2247	3898	10019	51836
%Δ	9.4%	19.8%	-49.6%	-3.7%	7.4%	20.0%	130.8%
Percent white	-2.0%	5.2%	-36.5%	-2.5%	-1.2%	-0.5%	78.3%
Percent black	0.6%	4.8%	-80.2%	-0.2%	0.2%	0.8%	33.3%
2000-2010	mean	sd	min	p25	p50	p75	max
Total Population	-15	96	-906	-16	-1	18	528
%Δ	7.7%	39.7%	-73.0%	-10.1%	-1.4%	11.9%	262.2%
Population Density (per sq. mile)	-62	389	-3682	-69	-2	76	2136
%Δ	7.6%	39.6%	-73.0%	-10.1%	-1.3%	11.6%	262.2%
Median Income	-1440	10349	-43042	-7867	-1099	5012	30245
%Δ	-2.0%	16.2%	-50.7%	-14.6%	-2.0%	9.6%	101.0%
Percent white	-2.8%	5.3%	-31.8%	-4.8%	-1.6%	0.2%	33.9%
Percent black	1.0%	4.1%	-28.6%	-0.8%	-0.1%	1.5%	31.0%

³⁰ It is important to note that while average total population change is negative, percentage change is positive. This suggests that communities with smaller populations are the ones experiencing the largest relative changes in population.

³¹ The summary statistics for these baseline demographic variables are listed in Table 3-1.

fixed effects t . Here, the change in total population and average population density are used to test for scale effects. The change in median income³² is used to test for the income effect. For the composition effect, the change in the share of white and the share of black are used. These dependent variables are summarized in Table 3-3. What results is a two-time period panel dataset, for years 2000 and 2010, regressed on changes between 1990 and 2000, and 2000 and 2010 respectively. For inference, the standard errors were estimated by clustering at the ZIP-code level to account for any correlations between unobservable of adjacent and closely located communities.³³ The variables, BL_{it} , New_{it} , and $Exit_{it}$ are binary variables for whether a community had baseline exposure in the previous time period, gained exposure between the previous time period and the current time period, and if all polluters have existed between the previous time period and the current time period. $Hazard_{it-1}$, $\Delta Hazard > 0_{it}$, and $\Delta Hazard < 0_{it}$ are continuous measures of exposure to pollution that capture the effect of the RSEI-hazard weighted pollution from the previous time period (BL), the positive change in hazard-weighted pollution, and the negative change in hazard-weighted pollution. Table 3-4 provides summary statistics for these six variables.

In this initial model, note that the coefficients for the discrete and continuous exposure variables are constrained to be the same for both time periods. Ten years is a long time to cover, and within each decade there are likely to be different underlying causes for firm exits and cleanups. Specifically, the coefficients for each time period are not likely to be the same.³⁴ Equation 2 is derived by letting the coefficients for these variables differ by year.³⁵

³² As previously mentioned, here, median income is technically the spatially weighted average of medians aggregated from block groups to the hexagon communities.

³³ Banzhaf and Walsh (2008) did not cluster standard errors, and assumed homoskedasticity.

³⁴ Banzhaf & Walsh 2008 ran something analogous to equation 1 in their paper, however, they only had one time period (1990-2000). Due to the one time period they also used ZIP Code fixed effects rather than community-level fixed effects.

³⁵ Likelihood ratio tests were conducted comparing results using Equations 1 and 2. The results from equation 2 were found to be statistically different at the .1% level.

Table 3-4: Change in TRI Exposure

1990-2000	mean	sd	min	max
Baseline Exposure (for all communities)	2.53e+08	3.04e+09	0.00e+00	9.53e+10
BL	0.17	0.38	0.00	1.00
Baseline Exposure (of exposed)	1.46e+09	7.18e+09	9.17e-01	9.53e+10
New	0.02	0.15	0.00	1.00
+Δ in Hazard	9.97e+08	5.76e+09	2.97e+00	3.69e+10
Exit	0.05	0.21	0.00	1.00
-Δ Hazard	-1.55e+08	9.96e+08	-8.70e+09	-9.17e-01
2000-2010	mean	sd	min	max
Baseline Exposure (for all communities)	1.10e+08	1.26e+09	0.00e+00	3.69e+10
BL	0.15	0.35	0	1
Baseline Exposure (of exposed)	7.35e+08	3.18e+09	4.18e-01	3.69e+10
New	0.03	0.16	0	1
+Δ in Hazard	4.03e+06	1.38e+07	1.94e-03	7.51e+07
Exit	0.04	0.20	0	1
-Δ Hazard	-8.99e+07	3.72e+08	-2.70e+09	-5.35e+00

Equation 2

$$\Delta y_{it} = \delta_0 + \alpha_t^{BL} BL_{it} + \alpha_t^{New} New_{it} + \alpha_t^{Exit} Exit_{it} + \beta_t^{BL\ Hazard} Hazard_{it-1} + \beta_t^{+\Delta} \Delta Hazard > 0_{it} \\ + \beta_t^{-\Delta} \Delta Hazard < 0_{it} + \delta^D D_{it-1} + \delta^{FE} FE_{it} + \varepsilon_{it}$$

Equation 2 allows for the estimation of different treatment effects for each time period, and it is the model used to estimate the final results of this paper. To derive the estimated average effects for baseline exposure, new exposure, and exits/cleanups it is necessary to combine both the estimated coefficient of the indicator variable, as well as the continuous variable. Specifically, the treatment effects are the linear combination of the coefficient for the indicator and the coefficient for the continuous measure of exposure multiplied by the average level of exposure or

exposure change. The different estimated treatment effects are described by the equations listed below³⁶.

Equations 3-7

Average Effect of Baseline Exposure (2000 – 2010)

$$= \hat{\alpha}_{t=2010}^{BL} + \hat{\beta}_t^{BL\ Hazard} \left(\frac{1}{N_{t=2010}^{BL}} \sum_{i \in BL_{2010}} Hazard_{it=2000} \right)$$

Average Effect of New Exposure (1990 – 2000)

$$= \hat{\alpha}_{t=2000}^{New} + \hat{\beta}_t^{+\Delta} \left(\frac{1}{N_{t=2000}^{New}} \sum_{i \in New_{2000}} \Delta Hazard > 0_{it=2000} \right)$$

Average Effect of New Exposure (2000 – 2010)

$$= \hat{\alpha}_{t=2010}^{New} + \hat{\beta}_t^{+\Delta} \left(\frac{1}{N_{t=2010}^{New}} \sum_{i \in New_{2010}} \Delta Hazard > 0_{it=2010} \right)$$

Average Effect of Exiting Exposure (1990 – 2000)

$$= \hat{\alpha}_{t=2000}^{Exit} + \hat{\beta}_t^{-\Delta} \left(\frac{1}{N_{t=2000}^{Exit}} \sum_{i \in Exit_{2000}} \Delta Hazard < 0_{it=2000} \right)$$

Average Effect of Exiting Exposure (2000 – 2010)

$$= \hat{\alpha}_{t=2010}^{Exit} + \hat{\beta}_t^{-\Delta} \left(\frac{1}{N_{t=2010}^{Exit}} \sum_{i \in Exit_{2010}} \Delta Hazard < 0_{it=2010} \right)$$

To further illustrate, the average effect of a cleanup between 1990 and 2000 would be the coefficient for $Exit_{it}$ plus the coefficient for $\Delta Hazard < 0_{it}$ multiplied by the average loss in exposure due to the firm(s) exiting between 1990 and 2000. This captures the effect of a firm exiting, as well as the average effect of the hazard reduction. More specifically it is an estimation of the average differential effect for a previously exposed community going from some exposure to no exposure (Banzhaf & Walsh, 2008).

³⁶ Baseline Exposure (1990-2000) could not be estimated due to collinearity between the other treatment effects and the community-level fixed effects.

Potential Limitations

Before the presentation of results, it is important to consider the potential limitations of this study. Firstly, while the aggregation of Census block group data into artificially generated communities allows for a time consistent and granular scale of analysis, it also introduces measurement error. As previously stated, median income, median rent, median home value, and median year built, were aggregated by taking a spatially weighted average of the values from the block groups. While this does not likely provide any significant bias, it does introduce bias nonetheless. Of course, if both block groups were dropped, the entire community would be dropped as well.

Another potential limitation is that this paper only looks at TRI pollution as a measure of environmental quality. The EPA's TRI data covers a wealth of chemicals; however, a community's actual and perceived environmental quality can be dictated by other factors. Parks, greenery, and open space are other factors that can differentiate communities in terms of environmental quality. Even if a community no longer is exposed to TRI emissions, it is possible that they are still behind other communities because of their lack of environmental goods. Given how environmental public goods are generally allocated³⁷, it is likely that most polluted neighborhoods also lack other environmental amenities that would make them attractive to wealthier households³⁸. This should generally be accounted for by the hexagon level fixed effects and other controls. If other environmental changes are moving in the same direction as changes in TRI exposure, this will overestimate the effect TRI exposure is having on communities, whereas there would be an underestimation if the other environmental changes were moving in the opposite direction of TRI changes. Perceptions of environmental quality are also important.

³⁷ A result from the predictions of Tiebout sorting.

³⁸ As well as households who have higher preferences for environmental quality.

Although all TRI facilities in a given area could be cleaned up, perceptions of communities as “dirty” or “polluted” may persist over time. This may cause households to be hesitant to move into previously polluted communities

The time frame of this study, 1990-2010, also introduces another potential issue in that it includes the 2008 financial crisis, and the resulting “Great Recession”. The models account for this with decade fixed effects, however, it is possible that there are several unknown factors affecting the results for the 2000-2010 variables. In some respects, however, Pittsburgh and the surrounding region was less affected by the Great Recession than the rest of the nation (Fee, 2009; Boselovic, 2018). Specifically, between 2007 and 2009, “Pittsburgh's unemployment rate [had] increased only 2.8 percent, while the national rate has increased 4.5 percent” (Fee, 2009). Pittsburgh's housing market, while undoubtedly affected, also did not suffer as much as many other cities—at least partially due to their lack of a real housing boom in the years preceding the recession (Boselovic, 2018). The combination of the decade fixed effects and the region's relative resistance to the recession means that while there may be some residual effects of the Great Recession on the results, they should not be too extreme.

With regards to the composition effect, while the Racial Income-Inequality Thesis and Tiebout thesis do provide a way to understand how environmental improvements can affect racial minorities, neither of them fully addresses discrimination or stratification as a factor in limiting mobility (Logan & Alba, 1993; Crowder & Downey, 2010). A fundamental aspect of the Tiebout theory is that everyone has full mobility, and historically, this has not been a reality, especially for African Americans (Crowder & Downey, 2010). Without access to credit or capital, it can be difficult to move—on a similar note, if a household lacks financial capital, their local social networks may be even more important to them, further hindering free mobility. Alternatively, research suggests racial discrimination by realtors in where they show homes and to whom (Turner et al., 2002; Turner & Ross, 2003). While this model does not directly take this into

account, the empirical estimation still can provide useful evidence for a composition effect. If, in fact, minorities do face more constraints and/or discrimination in moving, then the results in this paper can be seen as a lower bound. If short-term mobility is highly restricted, then the effect of environmental cleanup may cause greater displacement over a longer period of time for minorities. Similarly, if realtors are less likely to show white households homes in predominately black neighborhoods, then the results for white households can also be seen as a lower bound. While some white households may sort into predominantly black neighborhoods that have been cleaned, as the share of blacks decreases, realtors and white households may eventually be more interested in moving to said neighborhood.

In order to estimate this model, there is also an implicit assumption regarding the timing of gentrification versus the environmental improvement. Here, it is assumed that TRI facilities exit or are cleaned up exogenously from changes in community characteristics. This may not always be true. Specifically, it may be true that a TRI facility decision about locating and relocating with respect to the local community's characteristics. This would then lead to an endogeneity issue. However, similarly to Banzhaf and Walsh (2008), the expectation is that the spatial fixed effects, here at the hexagon community level, should help to address this.

Chapter 4

Results and Discussion

Regressions, more closely mirroring Banzhaf and Walsh (2008) were run individually for each decade (i.e. a regression only run on data from 1990-2000 and another one run only on 2000-2010). These results are in the Appendix section. The following sections present the results for the scale, income, and racial composition effects based off of Equation 2.

Scale Effect

Table 4-1: Scale Effect Results³⁹

	Baseline Exposure (2000-2010)	New Exposure (1990-2000)	New Exposure (2000-2010)	Exit/Cleanup (1990-2000)	Exit/Cleanup (2000-2010)	N/ R ²
Total Population	9.448 (13.741)	0.286 (18.676)	25.335* (13.120)	35.869*** (11.572)	-21.311 (13.525)	3430 0.870
% Change	-0.066 (0.077)	0.003 (0.103)	-0.146* (0.086)	-0.028 (0.059)	-0.030 (0.085)	3430 0.673
Population Density	26.702 (62.786)	-8.303 (67.387)	84.869 (53.365)	133.025*** (49.553)	-83.092 (53.525)	3430 0.876
% Change	-0.076 (0.078)	-0.016 (0.096)	-0.169** (0.081)	-0.022 (0.062)	-0.019 (0.085)	3430 0.674

* P<.1, ** p<.05, *** p<.01

To test for the scale effect that was predicted from Tiebout's sorting model, regressions were run using the change in total population, percentage change in total population, change in

³⁹ The demographic controls used for all regressions are: average population density, racial share (white, black, Latino, Asian, Native American), median year structure was built, median income, median home value, median rent, occupancy rate, renter rate, percent with a bachelor's degree, percent with less than a high school degree, percent employed in manufacturing or production, percent employed in managerial or professional positions, percent single female headed households, percent single male headed households, and percent unemployed (and their squared values). Individual hexagon and year fixed effects were also used. The standard errors were derived by clustering at the ZIP-code level.

average population density, and percentage change in average population density as the dependent variables. The results for the regressions are listed below in Table 4-1.

The results generally follow the intuition of Tiebout's model, however, there are a few unexpected results. Baseline exposure and new exposure would be expected to have a negative effect on population change, yet, there are multiple positive estimates. New exposure from 2000-2010 does have negative, statistically significant results for the percentage changes (-15 and -17 percentage points respectively). The total population change result for New Exposure (2000-2010), however, is positive. The data show that larger communities in Allegheny County, while they may experience absolute growth, often have lower percentage changes in population and density. The communities with smaller populations experienced the largest percentage increases in population. Ultimately in interpreting these results, this means that new exposure can lead to small increases in absolute population in largely populated communities, but still lead to smaller relative changes.

As can be seen with changes in total population and average population density, on average, TRI facility exits are associated with a 36 person increase between 1990 and 2000, or an increase in population density by 133 people per square miles. Both of these results are significant at the 1% level. This is a consistent result among the models, and it follows the earlier predictions.

Banzhaf and Walsh (2008) found consistently significant and clear effects regarding the scale effect. As compared to the results listed here, however, their estimations for changes in total population have greater magnitudes, while their estimations for the estimations for percentage changes in population are lower. These results cannot be clearly compared since, in defining the unique spatial scale for analysis, this paper used quarter square-mile hexagons, while they used half-mile circles.

Income Effect

Table 4-2: Income Effect Results

	Baseline Exposure (2000-2010)	New Exposure (1990-2000)	New Exposure (2000-2010)	Exit/Cleanup 1990-2000	Exit/Cleanup (2000-2010)	N/ R ²
Median Income	-471.246 (1116.564)	-4284.347** (1640.614)	-422.565 (1258.397)	1263.849 (1017.120)	-1381.409 (1535.036)	3430 0.851
% Change	-0.027 (0.021)	-0.061* (0.031)	0.001 (0.024)	0.022 (0.019)	-0.009 (0.025)	3430 0.861

* P<.1, ** p<.05, *** p<.01

The predictions from Tiebout's model generally suggest that improvements in environmental quality should lead to increases in income, while decreases in environmental quality should lead to decreases in income. However, as was discussed, the level of environmental change is what will dictate how many households from the richer community will migrate as compared to those from the poorer community. Marginal increases in environmental quality may not lead to significant changes in income, similarly with decreases. Baseline exposure, however, is consistently expected to be associated with lower incomes, all else held constant. Table 4-2 shows the results from the estimated regressions, where the change in median income and the percentage change in median income were used as the dependent variables.

Here, the effect of a TRI facility entrance between 1990 and 2000 was consistently estimated to have a negative effect on the change in income. This is consistent with the initial predictions. New exposure led to an almost \$4300, or a 6-percentage point decrease in median income within the 10-year period provides solid evidence that households value cleaner communities, or at least that they dislike polluted ones. This may be a result of richer households leaving these newly polluted communities, households from poorer communities now finding these newly polluted areas more affordable, or some combination of the two situations.

Most of the results have the expected sign, except that an Exit/Cleanup between 2000 and 2010 is estimated to have a negative effect, however, this effect is not statistically significant even at the 10% level. This is a curious result, that could potentially be associated with how important industry has been in Allegheny County over the years, even with the more recent decline. While Banzhaf and Walsh (2008) found consistently significant results for the income effect, the results here are somewhat unclear.

Composition Effect

Table 4-3: Composition Effect Results

	Baseline Exposure (2000-2010)	New Exposure (1990-2000)	New Exposure (2000-2010)	Exit/Cleanup 1990-2000	Exit/Cleanup (2000-2010)	N/ R ²
Share white	-0.025*** (0.009)	-0.015 (0.016)	-0.014* (0.008)	0.011* (0.007)	0.001 (0.012)	3430 0.821
Share black	0.023*** (0.008)	0.027*** (0.010)	0.008 (0.007)	-0.011** (0.005)	-0.002 (0.010)	3430 0.837

* P<.1, ** p<.05, *** p<.01

To estimate the composition effect, the change in the share of whites and the change in the share of blacks was used. While Tiebout's model does not present clear predictions on how improvements in environmental quality will affect the composition of a neighborhood, outside of income, the Racial Income-Inequality Thesis gives clear predictions for the racial composition effect. Here it is expected, that environmental improvements will attract white residents, while displacing black residents. The results of these regression are listed in Table 4-3.

The estimated average effects are exactly as expected. For the change in the share of blacks, while not consistently significant, baseline and new exposure, on average, cause increases and an Exit/Cleanup from 1990 to 2000 results in decreases in the change in the share of blacks. For whites, the estimated treatment effect of baseline exposure is negative, again as expected. The

other estimates are all the expected signs as well. This also mirrors the result found in Banzhaf and Walsh's discussion paper (2006), with similar levels of significance and magnitude. However, unlike Banzhaf and Walsh's 2006 discussion paper, this result provides statistically significant evidence with regard to cleanups. This presents evidence that black households experience less of the benefits of environmental cleanups or TRI firm exits than white households. This result is even more interesting given the relatively insignificant findings for exits with regards to the income effect, and somewhat inconsistent results for the scale effect. While communities may not necessarily gain an increase in median income from a cleanup, or increase their population, they are still estimated to experience a decrease in the share of blacks. Although economists often define gentrification through purely economic terms, there is a growing body of literature in other social science disciplines that think of it in terms of the processes of development, as well as neighborhood identity and culture (Ley, 1986, 2003; Maantay & Maroko, 2018). These results may provide quantitative evidence to these broader and more socially contextual definitions.

Discussion

The scale and income effects found in this paper are mostly consistent with what has been found in other similar papers (Banzhaf & Walsh, 2008; Gamper-Rabindran and Timmins, 2011), yet they lack consistent significance. This does suggest that there is some relationship between exposure to pollution and population and income—this relationship falls in line with preexisting findings. However, the results on their own do not give a clear indication for the presence of environmental gentrification. Instead, the racial composition effect gives the strongest evidence. In Allegheny County, there is consistent evidence suggesting that white and black households are oppositely related to environmental exposure. The findings here are exactly in line

with the theoretical expectations from the Racial Income-Inequality Thesis. Black households, due to systematically having less access to resources, appear to move to communities with TRI exposure (either preexisting or new). In contrast, white households tend to leave communities that have preexisting exposure or gain exposure. From 1990 to 2000, white households moved into communities that experienced an environmental cleanup at the same rate that the share of black households decreased. This is the opposite of the result found in one of the few other environmental gentrification studies of this type that test for racial composition effects. Economists, Gamper-Rabindran and Timmins, found that the share of blacks and Hispanics increases following the cleanup of Superfund sites (2011). These results for the racial composition effect have been under analyzed in the literature, and these results work to fill a gap.

There are two possible explanations for the findings of the racial composition effect that immediately stand out. First, it is possible that black households are being displaced by white households. Secondly, given that cleanups between 1990 and 2000 are also associated with increases in population, the majority of the new residents are white. The first explanation falls very in line with the more general narrative of gentrification, mainly, that improvements lead to displacement. However, as it has been noted by scholars, gentrification can go through different stages and may not be immediate (Ley, 1986, 2003). While displacement can still be an end result, this may not happen immediately. As previously discussed, the earlier stages of gentrification are often associated with shifts in local aesthetics and amenities towards middle class—and white—tastes (Smith, 1982; Sullivan & Shaw, 2011; Zuk et al., 2017; Ley, 2003). Although the income effect of environmental cleanups was statistically insignificant, race is highly interrelated with class (Brahinsky et al., 2014) as the Racial Income-Inequality Thesis also suggests. Due to institutionalized rules of discrimination and privilege, it is inappropriate to treat race and income inequality as completely separate issues. This reality means that the in-migration of white residents could signal possible future increases in income. There is also the potential for

compounding, where, as communities gain higher shares of white households, they then attract even more white households—possibly bringing higher incomes as well. Therefore, it is reasonable to suggest that, even if the second explanation is true, environmental gentrification may still be occurring.

There has not been much work done on environmental gentrification in Allegheny County or the Rust Belt, and the results found in this paper warrant further investigation. As a postindustrial region that is increasingly focused on greening and sustainable redevelopment, the implications of environmental gentrification can be quite concerning for environmental justice advocates. The evidence presented in this paper suggests that environmental cleanups, and possibly environmental development projects by extension, can cause the in-migration of new residents. This may be seen as a benefit, especially in a region that is experiencing declining populations. The income effect presented here, while inconsistent in statistical significance, does indicate that pollution is at least detrimental to local income—suggesting that wealthier residents are responsive, at least, to declines in local environmental quality. These results for the scale and income effects suggest that environmental cleanups in Allegheny County can benefit local government through increasing population and potentially increasing incomes. However, environmental cleanups do not benefit all households equally. In order to ensure environmental justice and equity, caution should be taken to make sure that race and class are not barriers to cleaner environments.

Chapter 5

Conclusion

By testing for environmental gentrification in Allegheny County from 1990 to 2010 using the EPA's Toxic Release Inventory, this paper found mixed evidence of the more commonly tested scale and income effects and compelling evidence of the under analyzed racial composition effect. Environmental gentrification poses a serious threat to the goals of the EJM, and the evidence here suggests that there may be an environmental justice issue associated with TRI cleanups in Allegheny County. While much of the existing literature has ignored or avoided composition effects, this paper is unique in that the racial composition effect is ultimately the most compelling result. It also parallels the findings of Gould and Lewis (2017) and Crowder and Downey (2010), while contrasting the findings of Gamper-Rabindran and Timmins (2011).

The results of the racial composition effect are even more interesting in the face of the mixed results for the scale and income effect. While there is evidence that environmental cleanups attract white households, it is unclear if these households have higher incomes than residents of the cleaned community. But, as discussed, even if these new residents are not significantly richer than the incumbent households, gentrification can still unfold. Gentrification is often associated with displacement, and while this may still be a result, the early stages of gentrification can be identified by changes in housing developments, retail space, and local amenities. This opens a possible path for future research. Specifically, there is a need to better understand how communities, especially those in postindustrial regions, change at a social level following cleanups or environmental developments. This work in particular would benefit from a more qualitative approach—or primary data collection—given the difficulty in capturing such nuances and changes in secondary data analysis. Such an analysis may also find a more socially relevant spatial scale of analysis. The discrepancy between the income and racial composition

effect could also be explored by an improved understanding of the relationship between race and realty. This line of questioning could be concerned with how race determines what neighborhoods realtors show households when moving. Specifically, for gentrification, it could investigate how people learn about “up-and-coming neighborhoods”—including those with new environmental developments or cleanups—and if a racial bias is present.

There is also a need to further investigate the demand effects, which may allow for a more comprehensive test for environmental gentrification. Other papers have tested for these effects, by analyzing the effects of environmental improvements on home values, rent, and housing affordability (Greenstone & Gallagher, 2008; Immergluck & Balan, 2017). These demand effects would consider the effects of baseline and new exposure, as well as cleanups, on households’ demand for living in a community. It may also consider how these treatments affect the rate of housing development. Since gentrification is often characterized by new housing developments, a positive coefficient for TRI cleanups could also provide evidence of a gentrifying process.

Finally, more work could be done on the topic of environmental gentrification. While there is a lot of work that has been done, most studies seem to either focus on either a singular environmental amenity or disamenity. Moving towards a more comprehensive analysis of the developments and changes under the “greenwave”⁴⁰ (Checker, 2011) could lend to a better understanding of who truly benefits from environmental improvements—based on income, race, and other demographic characteristics. Explicitly, in the economics literature on gentrification, more could be done to improve the methods used, including the use of mixed-methods and longitudinal, micro-level data. Many studies have focused heavily on either quantitative or qualitative methods, however, due to the complicated nature of gentrification, it may be necessary

⁴⁰ Another term describing the growing interest in the sustainable development movement.

to implore a more diverse approach. Focusing purely on the outcomes of gentrification (i.e. scale, income, and composition effects), may miss the nuance gained from understanding the processes that catalyze it in the first place. Understanding the distributional effects of environmental improvements is crucial to ensuring environmental equity and justice.

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Appendix A

Tables

Table A-1: Baseline Summary Statistics (1990)

	mean	sd	min	p25	p50	p75	max
Total Population	362	556	17	56	135	387	4,122
Population Density (per sq. mile)	1,499	2,283	68	229	563	1,596	16,815
Percent white	94.6%	12.1%	1.6%	95.7%	97.4%	98.8%	100.0%
Percent black	4.2%	12.0%	0.0%	0.3%	1.4%	2.7%	97.0%
Percent Native American	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%	0.7%
Percent Asian	0.6%	1.0%	0.0%	0.1%	0.3%	0.7%	12.5%
Percent Latino	0.5%	0.3%	0.0%	0.2%	0.4%	0.7%	2.5%
Median Income	57,312	21,958	14,193	45,274	52,826	66,581	194,088
Median Home Value	113,878	77,836	27,012	82,540	96,978	122,558	697,789
Median Rent	709	200	244	582	670	812	1,621
Median Year Structure Built	1959	10	1933	1953	1958	1967	1985
Percent with less than high school diploma	20.5%	8.7%	0.8%	13.7%	20.3%	25.5%	51.1%
Percent with at least a bachelor's degree	20.0%	13.2%	1.6%	9.8%	15.0%	28.1%	79.1%
Percent employed in managerial positions	27.6%	10.7%	3.3%	19.6%	25.7%	33.1%	67.8%
Percent employed in production positions	13.4%	7.0%	0.0%	8.1%	12.7%	17.1%	44.6%
Percent unemployed	6%	4%	0%	3%	5%	7%	54%
Percent single parent (male)	2.8%	1.0%	0.5%	2.1%	2.7%	3.4%	7.4%
Percent single parent (female)	9.7%	5.2%	2.6%	6.6%	8.7%	10.6%	76.0%
Occupancy Rate	94.4%	3.6%	57.2%	92.9%	95.2%	96.8%	100.0%
Vacancy Rate	5.6%	3.6%	0.0%	3.2%	4.8%	7.1%	42.8%
Percent renter-occupied	22.5%	14.6%	1.4%	11.8%	18.7%	29.9%	91.5%

Table A-2: Baseline Summary Statistics (2000)

	mean	sd	min	p25	p50	p75	max
Total Population	342	501	13	54	144	393	4,240
Population Density (per sq. mile)	1,418	2,056	54	224	599	1,619	17,147
Percent white	92.5%	13.1%	1.5%	94.0%	96.2%	97.5%	99.6%
Percent black	4.9%	12.6%	0.0%	0.7%	1.4%	3.0%	95.3%
Percent Native American	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.7%
Percent Asian	1.1%	1.5%	0.0%	0.2%	0.6%	1.3%	15.9%
Percent Latino	0.6%	0.4%	0.0%	0.4%	0.6%	0.8%	3.3%
Median Income	61,471	22,383	14,700	47,847	56,332	69,868	190,619
Median Home Value	134,305	99,156	28,846	96,179	112,790	148,481	836,790
Median Rent	760	267	279	583	688	872	2,535
Median Year Structure Built	1,960	11	1,937	1,954	1,959	1,966	1,991
Percent with less than high school diploma	14%	6%	1%	9%	13%	17%	39%
Percent with at least a bachelor's degree	24.8%	14.9%	3.4%	13.3%	19.0%	35.4%	77.0%
Percent employed in managerial positions	34.9%	11.7%	10.8%	25.7%	32.5%	42.1%	78.7%
Percent employed in production positions	22.9%	8.8%	3.1%	16.1%	22.1%	30.6%	42.8%
Percent unemployed	4.8%	3.3%	0.0%	2.7%	4.3%	6.0%	28.8%
Percent single parent (male)	3.4%	1.2%	0.9%	2.5%	3.4%	4.1%	7.7%
Percent single parent (female)	9.9%	4.9%	2.9%	7.0%	8.8%	11.6%	50.4%
Occupancy Rate	93.7%	3.9%	59.9%	92.5%	94.6%	96.1%	99.2%
Vacancy Rate	6.3%	3.9%	0.8%	3.9%	5.4%	7.5%	40.1%
Percent renter-occupied	22.3%	14.3%	2.1%	12.2%	17.6%	29.3%	83.3%

Table A-3: Pairwise Correlations (1990)

	Total Hazard	Total Population	Population Density	Median Income	Percent white	Percent black
Total Hazard	1					
Total Population	0.0532**	1				
Population Density	0.0594**	0.9981***	1			
Median Income	-0.0698***	-0.2155***	-0.2228***	1		
Percent white	-0.0646***	-0.3947***	-0.3944***	0.1722***	1	
Percent black	0.0667***	0.3797***	0.3796***	-0.2085***	-0.9960***	1

* P<.1, ** p<.05, *** p<.01

Table A-4: Pairwise Correlations (2000)

	Total Hazard	Total Population	Population Density	Median Income	Percent white	Percent black
Total Hazard	1					
Total Population	0.0274	1				
Population Density	0.0355	0.9979***	1			
Median Income	-0.0598**	-0.2528***	-0.2619***	1		
Percent white	-0.0045	-0.4642***	-0.4643***	0.2539***	1	
Percent black	0.0063	0.4281***	0.4287***	-0.2911***	-0.9897***	1

* P<.1, ** p<.05, *** p<.01

Table A-5: Pairwise Correlations (2010)

	Total Hazard	Total Population	Population Density	Median Income	Percent white	Percent black
Total Hazard	1					
Total Population	0.0469*	1				
Population Density	0.0541**	0.9973***	1			
Median Income	-0.0372	-0.2789***	-0.2892***	1		
Percent white	-0.0176	-0.4505***	-0.4511***	0.3083***	1	
Percent black	0.0186	0.4111***	0.4120***	-0.3512***	-0.9533***	1

* P<.1, ** p<.05, *** p<.01

Table A-6: Results (1990-2000)

	Baseline Exposure	New Exposure	Exit/Cleanup	N/R ²
Total Population	-39.553*	-25.378**	-10.991	1702
	(21.874)	(11.816)	(14.289)	0.551
% Change	-.001	-.033	-.026	1702
	(.080)	(.053)	(.065)	0.170
Population Density	-150.791*	-101.856**	-45.446	1702
	(89.576)	(45.096)	(60.980)	0.542
% Change	.010	-.041	-.017	1702
	(.081)	(.050)	(.067)	0.173
Median Income	-2044.431*	-1105.811	-441.341	1702
	(1140.326)	(1800.226)	(915.848)	0.608
% Change	-.038*	-.021	-.021	1702
	(.022)	(.028)	(.017)	0.659
Percent white	-.030*	-.006	0.004	1702
	(.017)	(.008)	(.007)	0.614
Percent black	.031*	.004	-.003	1702
	(.016)	(.005)	(.006)	0.598
* P<.1, ** p<.05, *** p<.01				

Table A-7: Results (2000-2010)

	Baseline Exposure	New Exposure	Exit/Cleanup	N/R ²
Total Population	11.166 (8.567)	-1.170** (11.032)	-9.954 (9.302)	1702 0.552
% Change	-.028 (.035)	-.098* (.057)	.009 (.038)	1702 0.515
Population Density	51.382 (35.460)	-10.641 (40.479)	-51.869 (40.774)	1702 0.554
% Change	-.027 (.036)	-.106** (.053)	0.006 (.040)	1702 0.516
Median Income	377.701 (748.799)	-1946.22 (1527.65)	-99.014 (1727.129)	1702 0.563
% Change	-.003 (.013)	-.034 (.023)	-.002 (.028)	1702 0.546
Percent white	-.005 (.009)	-.014 (.009)	-.013 (.011)	1702 0.444
Percent black	.009 (.007)	.013 (.009)	-.001 (.009)	1702 0.424
* P<.1, ** p<.05, *** p<.01				

Appendix B

Maps

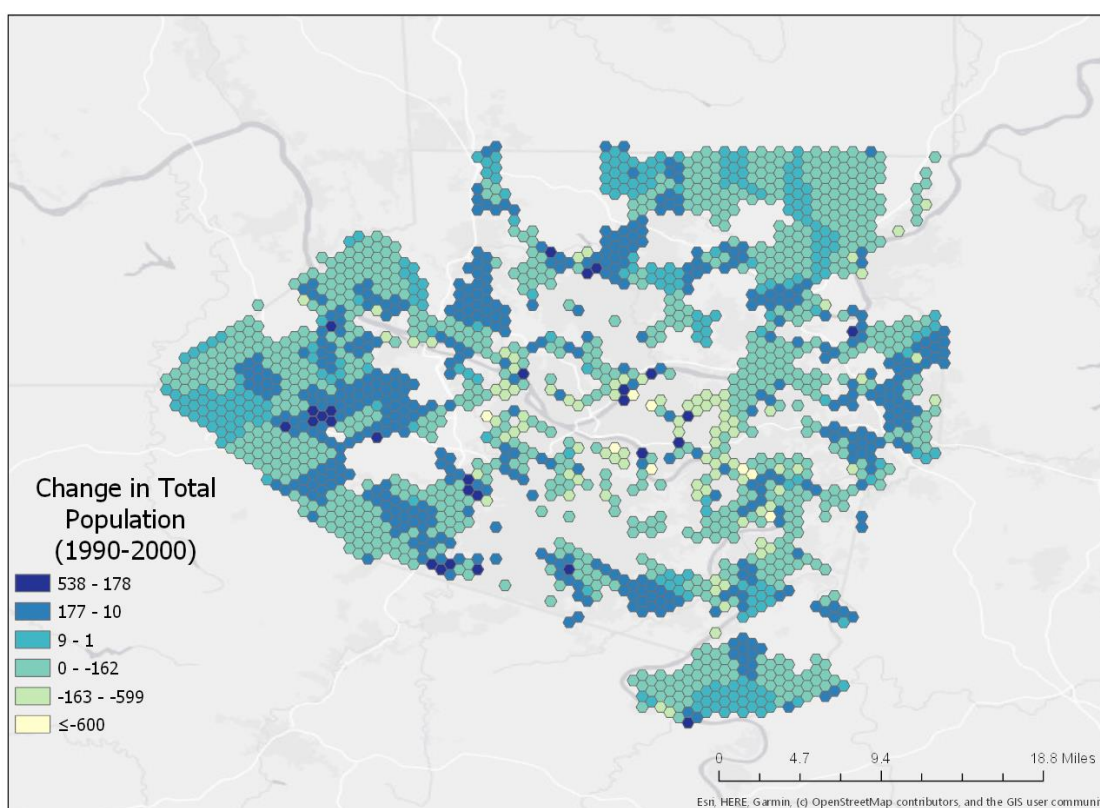


Figure B-1: Change in Total Population (1990-2000)

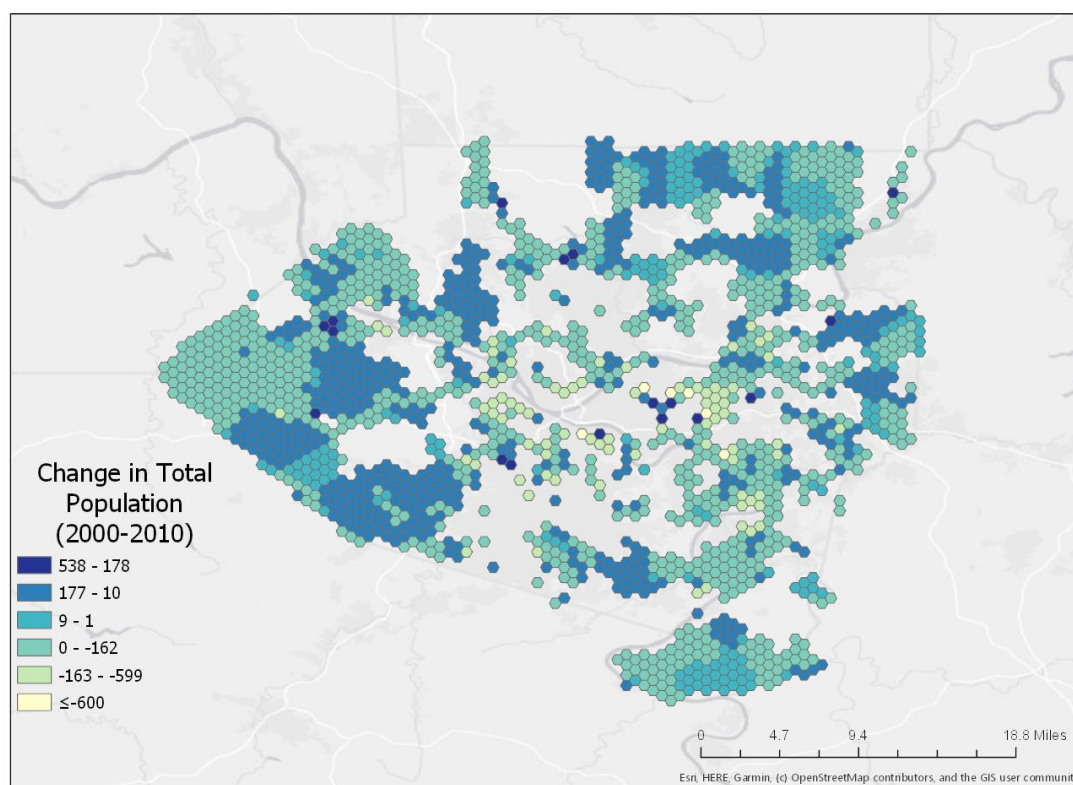


Figure B-2: Change in Total Population (2000-2010)

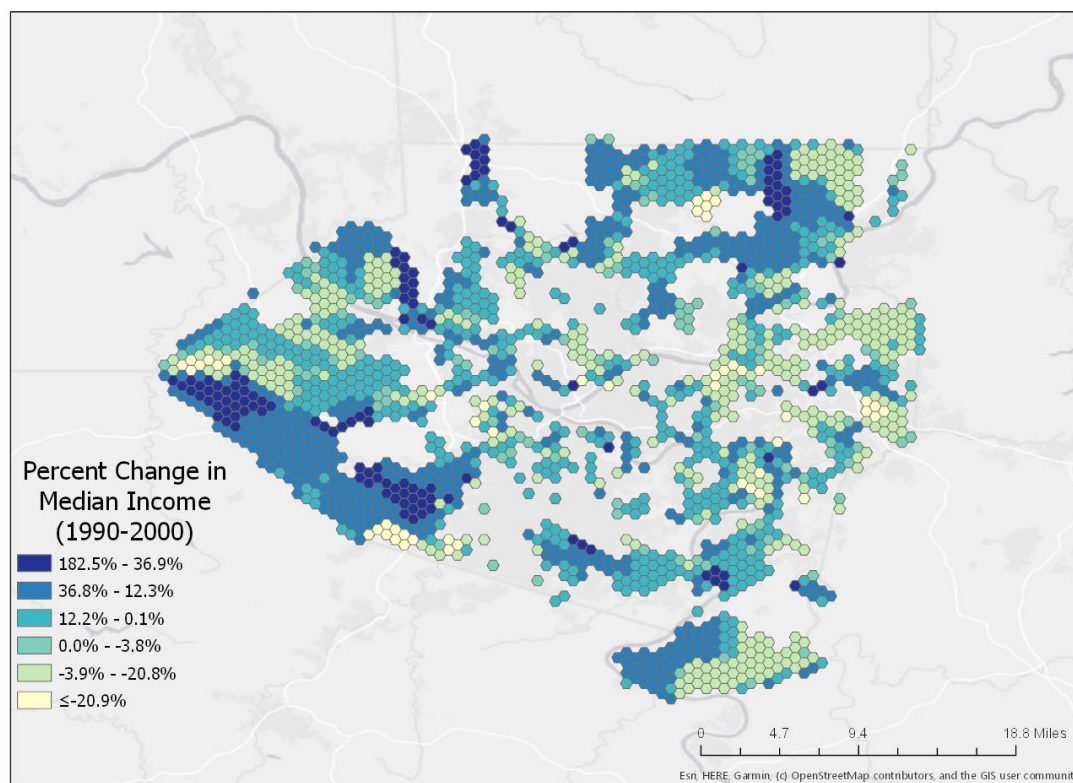


Figure B-3: Percent Change in Median Income (1990-2000)

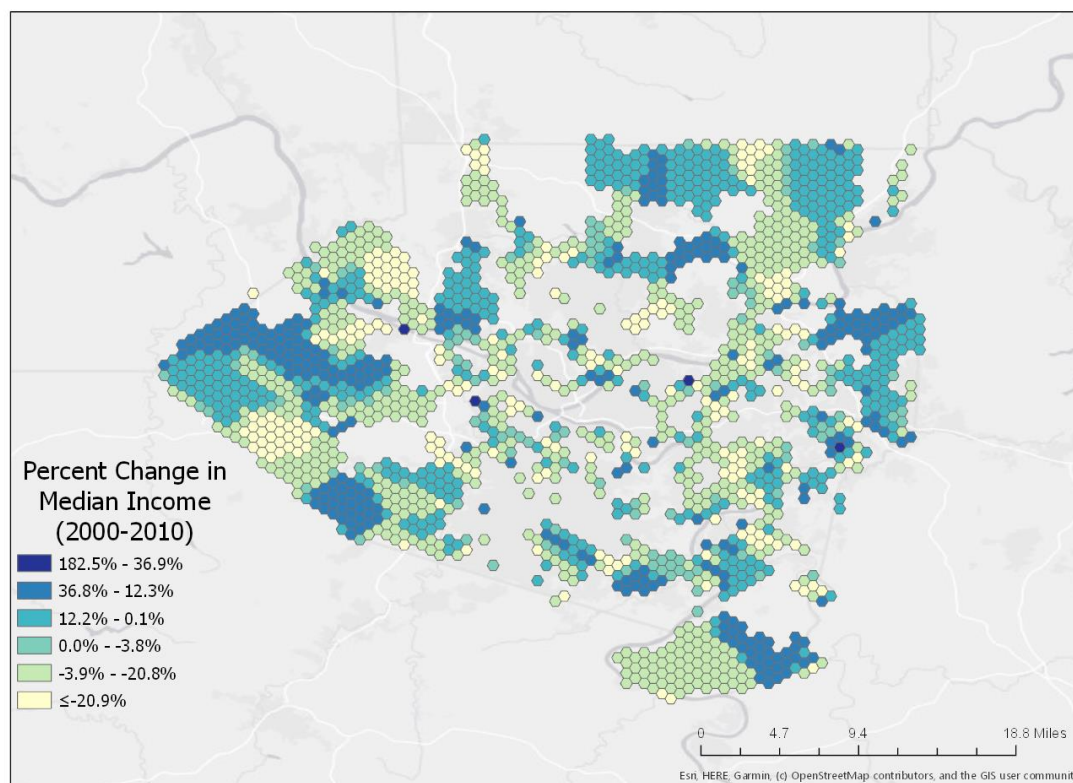


Figure B-4: Percent Change in Median Income (2000-2010)

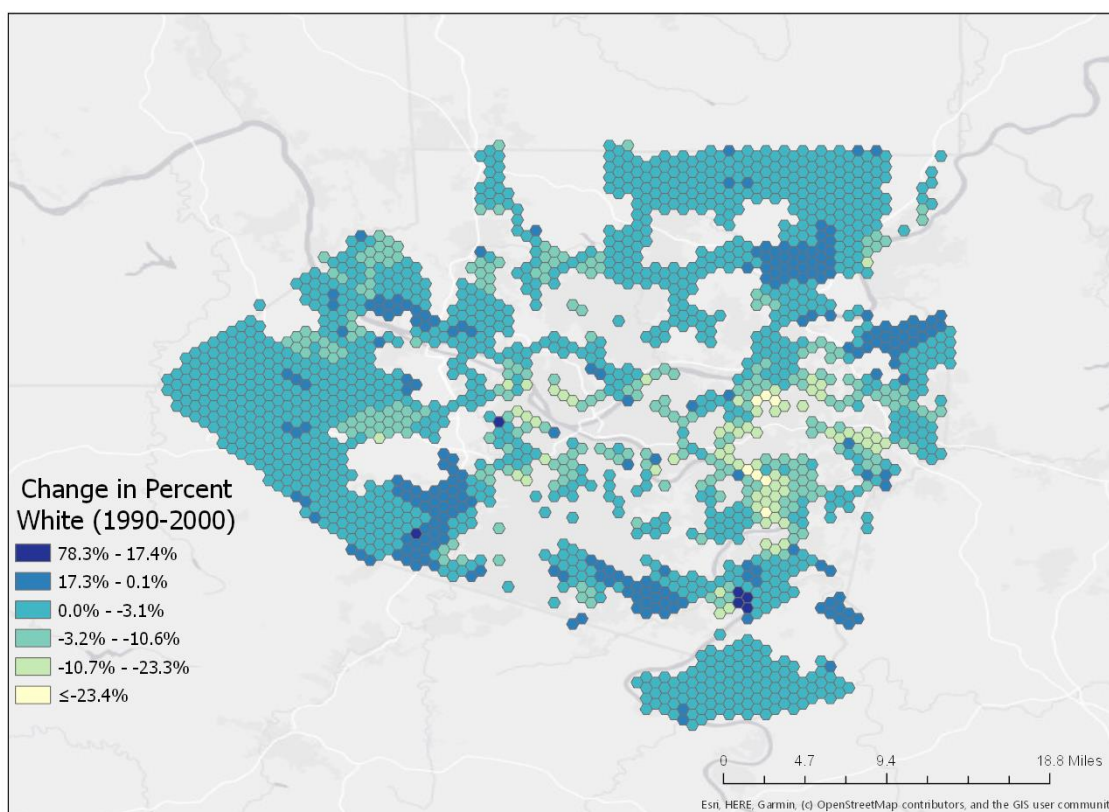


Figure B-5: Change in Percent White (1990-2000)

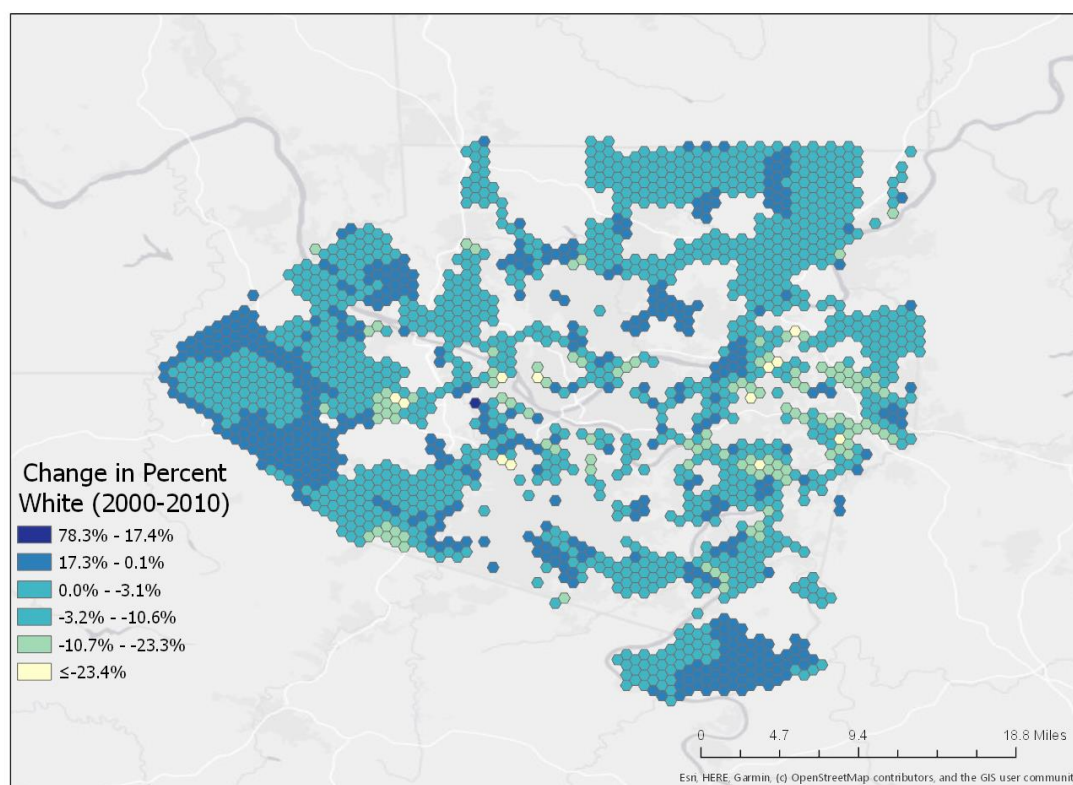


Figure B-6: Change in Percent White (2000-2010)

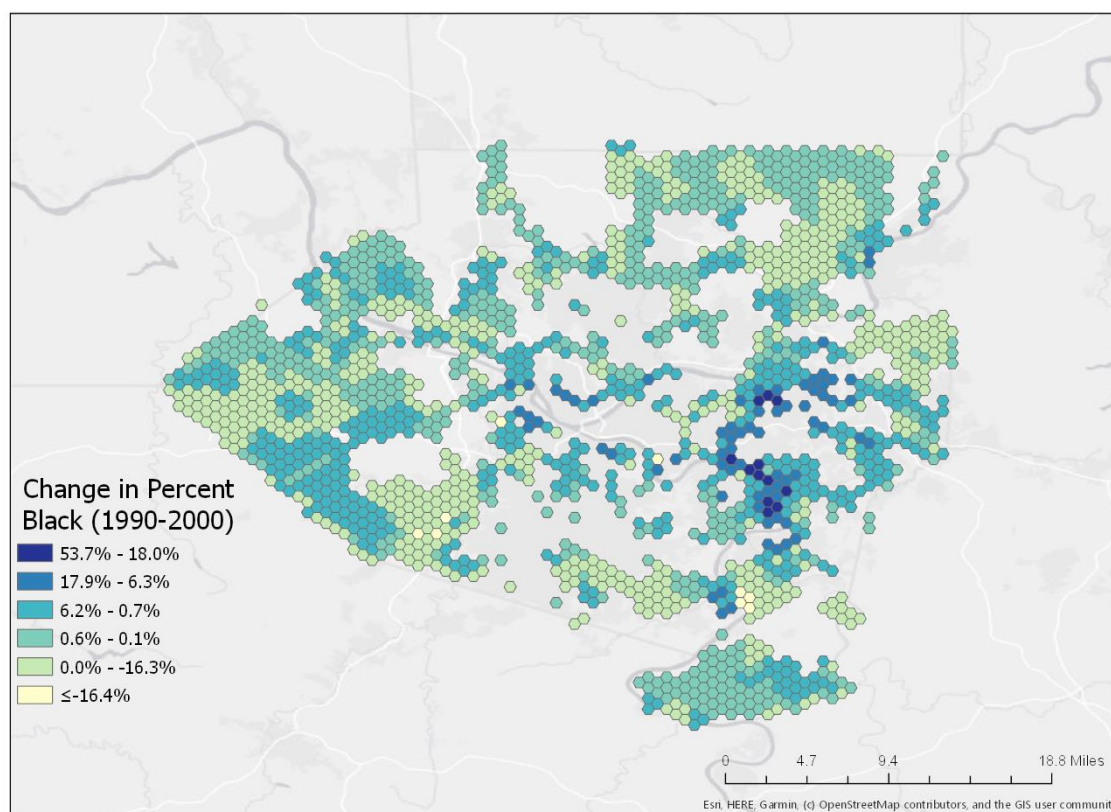


Figure B-7: Change in Percent Black (1990-2000)

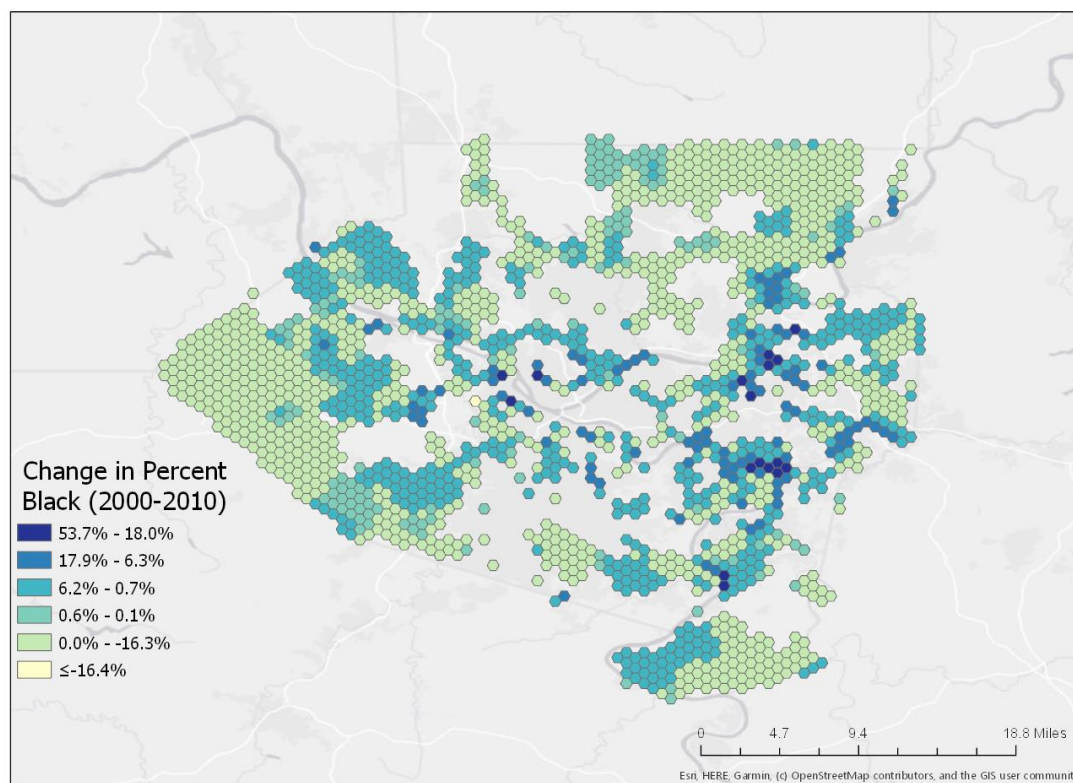


Figure **B-8**: Change in Percent Black (2000-2010)

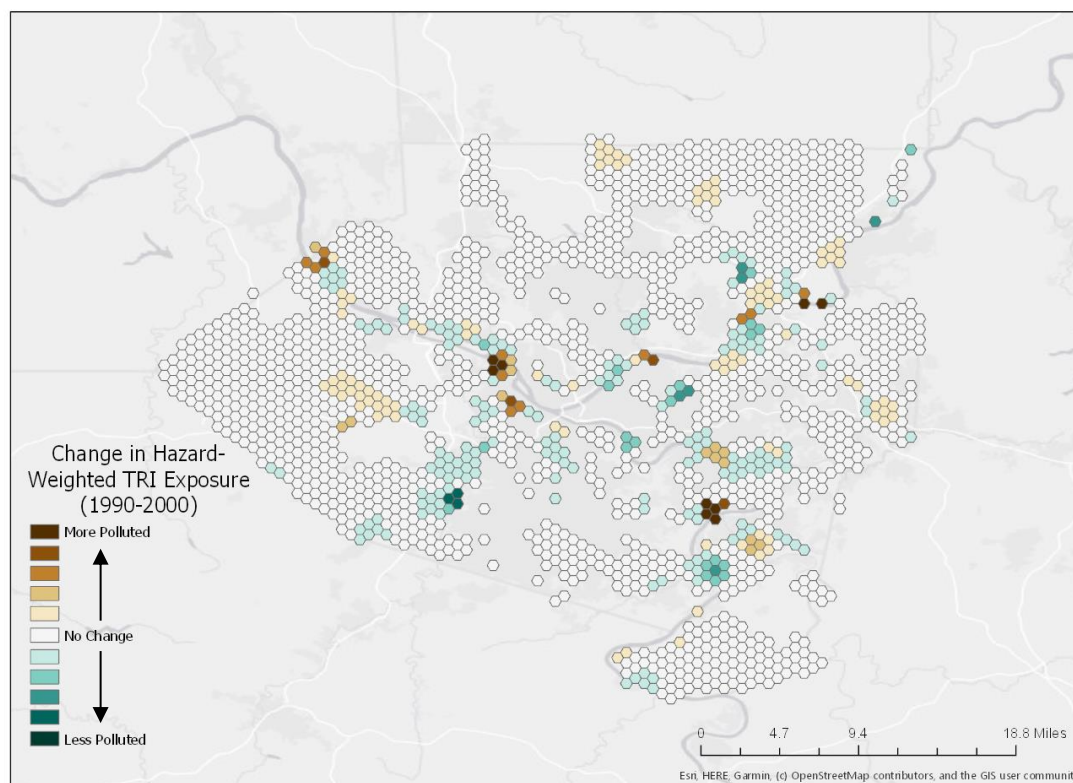


Figure B-9: Change in TRI Exposure (1990-2000)

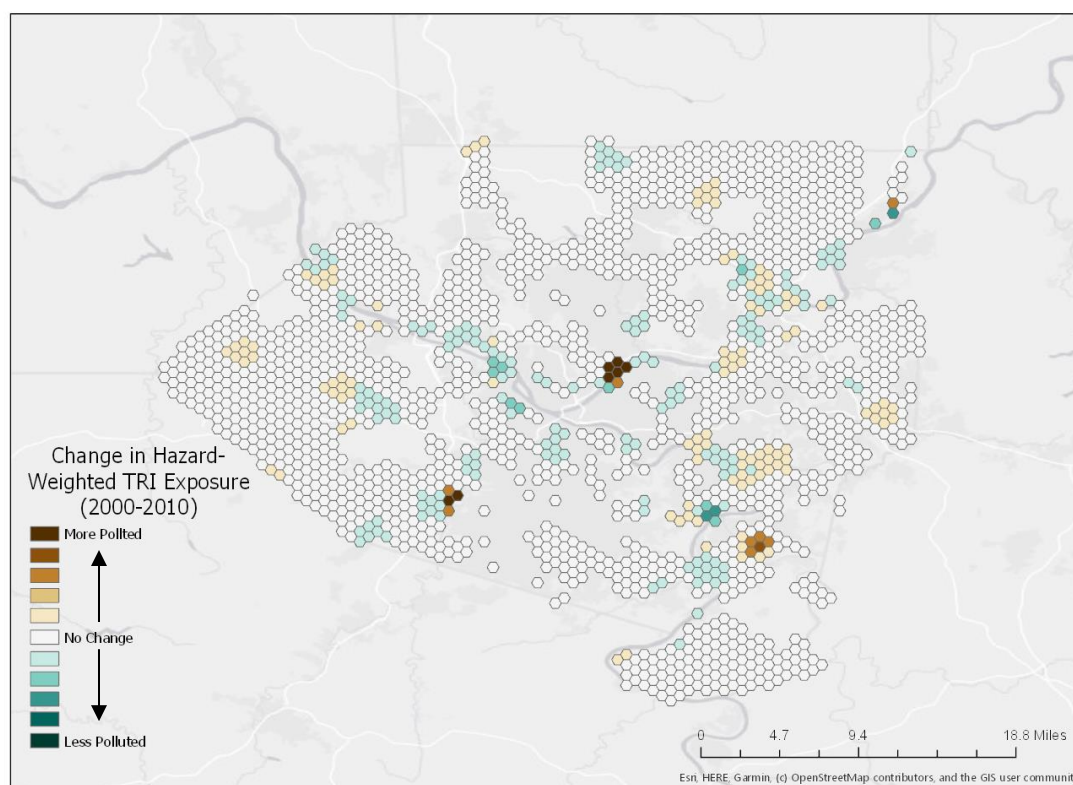


Figure B-10: Change in TRI Exposure (2000-2010)