Which Came First,
Coal-Fired Power Plants or Communities of Color?

Assessing the disparate siting hypothesis of environmental injustice

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ABSTRACT

Although a considerable amount of quantities environmental justice research exists, most studies have focused on the *current* distribution of environmental hazards, leaving out discussion on how and why such injustices occur. Further, of the handful of studies that have examined the processes by which racial and socioeconomic disparities have emerged, the majority have focused exclusively on the siting of hazardous waste Treatment, Storage, and Disposal Facilities (TSDFs), only a subset of all polluting facilities. This study is the first national-level longitudinal study using distance-based methods to examine the disparate siting hypothesis concerning coal-fired power plants (CFPPs). The purpose of this study is to determine if there are current (2010) racial and socioeconomic disparities around U.S. CFPPs and if so, whether such disparities were present at the time of siting. In particular, this study assesses whether there were differences in the patterns of disparate siting across decades prior to, during, and after the emergence of the modern environmental and environmental justice movements. Results show present-day (2010) racial and socioeconomic disparities for existing CFPPs, and lend support for hypotheses that increased environmental awareness in the 1960's and 1970's, as well as increased environmental justice awareness and activism in the late 1980's onwards, influenced CFPP siting in communities of color. However, race disparities independent of socioeconomic factors were found to be significant predictors of CFPP siting from 1965 to 1974 only, a smaller window than found by prior studies for TDSFs. Socioeconomic variables were significant independent predictors of facility siting in time periods between 1945 and 1954, 1965 and 1974, and 1984 and 1995.

Keywords: siting, environmental justice, energy justice, coal-fired power plants

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ABBREVIATIONS

CFPP(s) - Coal-Fired Power Plant(s)

CAA – Clean Air Act

eGRID – Existing Electric Generating Units in the United States database

EIA – U.S. Energy Information Administration

EPA - Environmental Protection Agency

GIS – Geographic Information Software

LULU(s) – locally unwanted land-use(s)

MW - megawatts

NAACP - National Association for the Advancement of Colored People

NO_x – nitrogen oxide

NIMBY- not in my backyard

SO_2 – sulfur dioxide

TRI – Toxic Release Inventory

hazardous waste TSDFs – hazardous waste Treatment, Storage, and Disposal Facilities

UCC – United Church of Christ

U.S. – United States

CHAPTER ONE: Introduction

From the siting of a hazardous waste landfill in Warren County, North Carolina to the exorbitantly high water lead levels in Flint, Michigan, cases of environmental injustices are not isolated or infrequent events. Present-day injustices, national and local, have been thoroughly established in environmental justice literature for a wide variety of pollution sources and other environmental hazards (Mohai, Pellow, and Roberts 2009). In particular, many studies have found a correlation between pollution burdens and racial and socioeconomic disparities (Bullard et al. 2007; Mohai and Saha 2006, 2015a, 2015b; Pais, Crowder, and Downey 2013; Ringquist 2005; Zwickl, Ash, and Boyce 2014). Since the early 1980's, research has supported the claim that hazardous waste sites, high per capita criteria pollutant emissions, and air toxics facilities are disproportionately located in areas with high rates of marginalized groups (Bullard et al. 2007; Chavis and Lee 1987; Carson, Joen, and McCubbin 1997; Bryant and Mohai 1992). Strong social movements and substantial public policy efforts have paralleled the academic establishment of environmental justice, including several conferences and working groups, a federal office of Environmental Justice, and regular EPA Environmental Justice Action Agendas (Grafton et al. 2015; Perez et al. 2015; Taylor 2000; Brulle and Pellow 2006, Bullard et al 2011; Rosenbaum 2011).

Since the early 2000's, the disparate hazards generated from coal-fired power plants (CFPPs) have been a focus of environmental justice advocacy (LVEJO 2014; Sierra Club 2017). Specifically, the Sierra Club and other local environmental justice organizations have launched widespread grassroots campaigns to move "beyond coal" and retire the nations' coal-burning plants in the face of climate change (Sierra Club 2017). As a result, attention has been drawn to the environmental and public health risks posed by these plants. In particular, research based on the Toxics Release Inventory has noted that the electric power industry is the largest toxics polluter in the United States, of which coal is the most toxic when compared to other fuels (National Environmental Trust 2000). Likewise, emissions from CFPPs have been linked with individual pollutants that are known to cause cancer, impair reproductive health and child development, damage nervous and immune systems, cause respiratory conditions such as asthma, and increase rates of strokes, heart attacks, and premature death (Keating 2001; Schneider 2010).

Most recently, the National Association for the Advancement of Colored People (NAACP) studied U.S. CFPPs and evaluated their distribution against population demographics (Wilson et al. 2011). Overall, results indicated that the average per capita income within three miles of CFPPs was lower than the national average, and the percent nonwhite population within three miles of CFPPs was higher than the national average (Wilson et al. 2011). Their findings imply that the health risks generated from CFPPs are disproportionately concentrated in our most at-risk communities - communities of color and low-income communities - highlighting a clear environmental justice issue.

Traditional environmental justice research, such as the NAACP study, provides valuable insight on the current social distribution of environmental hazards. However, the existence of present-day racial and socioeconomic disparities has prompted scholars and policymakers to search for explanations of why and how these disparities occur (Mohai and Saha 2015b). In order to seek equitable and adequate solutions to environmental justice, we must first understand the context in which disparities have emerged. In particular, more research should focus around the questions that a number of scholars have raised (Mohai and Saha 2015a, b; Pastor, Sadd, and Hipp 2001; Taylor 2014): (1) which came first: the environmental hazard or low-income communities of color? and (2) who or what keeps low-income people and people of color in environmental conditions that are detrimental to their health?

Several theoretical explanations for the causes of socio-environmental disparities consider economic, sociopolitical, and racial-discriminatory factors, discussed in Chapter 2. However, most environmental justice studies have been unable to address the questions of 'why' and 'how' because they have been cross-sectional snapshot studies highlighting disparities at only a single point in time (Mohai and Saha 2015 a,b). Furthermore, the few longitudinal studies that do exist have provided mixed empirical evidence for two causal processes: post-siting demographic change and disparate siting. The former process involves demographic changes *after facility siting* resulting in higher concentrations of low-income communities of color around such sites, while the latter involves the disproportionate placement of hazardous facilities in low-income communities of color *at the time of siting* (Mohai and Saha 2015a).

Mohai and Saha (2015b) addressed these research gaps by conducting the first national-level environmental justice study that employed longitudinal analyses using a distance-based approach (discussed in Chapter 2). Their results confirmed strong evidence of disparate siting of hazardous waste treatment, storage, and disposal facilities (TSDFs) in all time periods from 1970 to 2000, and some evidence of post-siting demographic changes that were in continuation of changes that already began occurring prior to siting. This supports hypotheses that hazardous facilities are more likely to have been placed in low income, communities of color or transitioning, vulnerable communities at the time of siting. Previously, in 2005, Saha and Mohai published a study on the siting of hazardous waste TSDFs in Michigan alone, and was the first to find that historical context, such as development of the environmental movement and Not-In-My-Backyard sentiments (NIMBY-ism), influenced the siting of hazardous facilities in low-income, communities of color. These two studies highlight important findings about the timing of disparities and the influence of outside factors, however focused exclusively on hazardous waste TSDFs.

In order to answer the questions of 'why' and 'how' on a broader scale, more studies are needed that employ longitudinal analyses using distance-based methods for polluting sources beyond hazardous waste TSDFs. The following study examines the demographic characteristics of communities surrounding CFPPs at the time of plant siting. This study is the first national-level longitudinal studying using distance-based methods to examine the disparate siting hypothesis concerning CFFPs. In particular, an important contribution of this study is to determine whether the patterns Mohai and Saha (2015b) found for hazardous waste TSDFs are generalizable to other environmental hazards. Therefore, the objective of this study is to advance our understanding of the unequal burden that environmental problems impose on low-income and minority groups and draw attention to other factors in which inequalities have been created and sustained. The study will examine whether racial/ethnic and socioeconomic disparities exist for present-day host communities of CFPPs and will determine whether current disparities arise from changes in community composition at the time of coal power plant construction.

It is important to have a comprehensive account of all of the factors by which our society has distributed unequal burdens of pollution onto disadvantaged communities. As government entities attempt to create equitable policy in the face of retiring CFPPs, incorporate new energy sources, analyze the increasing effects of climate change, and resurge the use of coal power, it will be important to understand how and when current disparities came about. Vulnerable communities can be engaged in the achievement of better advocacy and remediation efforts by having more information on the manner in which environmental injustices are carried out.

Research Questions

In examining demographic characteristics within U.S. coal plant host communities at the time of plant siting and in 2010, this study will explore the following research questions:

1. Are there current (2010) racial and socioeconomic disparities between areas in the U.S. hosting CFPPs and those not hosting CFPPs?
2. Are current disparities surrounding CFPPs a result of disparate siting?
3. Are there differences in the patterns of disparate siting across decades prior to, during, and after the emergence of the modern environmental and environmental justice movements?

Using the areal apportionment method (see Chapter 2 and Mohai and Saha 2006) to compare areas with and without CFPPs, this study assessed the generalizability of the findings from other studies assessing hazardous waste TSDF siting, such as that of Mohai and Saha (2015b). Based on historical context and existing studies elaborated on below, it is hypothesized that racial and socioeconomic disparities between host and non-host CFPP communities will be greater than the surrounding area for plants sited in the mid-1960's onward, as a result of increased environmental awareness and NIMBYism.

The subsequent chapters of this thesis begin with a literature review that examines the historical context of the environmental and environmental justice movements and existing research on the distributions of environmental burdens. Chapter 3 then outlines the regulations, health impacts, and existing knowledge of CFPPs. Next, Chapter 4 describes data acquisition as well as the spatial and quantitative methodology used in the analysis, and Chapter 5 contains the results of such analyses. Finally, Chapter 6 includes a discussion of the findings related to prior studies and directions for future research.

<u>CHAPTER TWO:</u> Existing Studies & Historical Context

To better understand the relationship between low-income communities, communities of color, and CFPPs, it is necessary to first become familiar with existing research on the distribution of environmental hazards and historical context influencing such distributions.

The Environmental Justice Movement

Research that focuses on the distribution of environmental hazards, in particular, their impact on low-income populations, people of color, and other minority groups, is referred to as environmental justice research. Yet, there are several definitions for environmental justice or injustice. Bullard (1996) defines environmental justice as "the principle that all people and communities are entitled to equal protection of environmental and public health laws and regulation" (pp. 493). Whereas the U.S. Environmental Protection Agency (EPA) (2017b) defines environmental justice as "the fair treatment and meaningful involvement of all peoples regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies". An environmental injustice exists when members of a disadvantaged group – ethnic, social, or other minority – are suffering unequally at a local, regional, or national level from environmental hazards (Wilson et al. 2011). Much environmental justice work focuses on the evidence of injustice along racial lines, known as environmental racism. More specific than environmental justice, environmental racism refers to any environmental policy, action, or decision that differentially affects or disadvantages individuals, groups, or communities based on race or ethnicity (Bullard 1993; Taylor 2000). Although closely researched today, environmental justice, environmental racism, and the impacts of environmental hazards on human health where not always well-known or well-protected.

Throughout the 1960's and 1970's, the publication of Rachel Carson's *Silent Spring* was a particularly influential example of many reports, books, and events that began to shape public environmental awareness and concern. It prompted widespread alarm over how industrial practices negatively affect human and ecosystem health, marking the beginning of the environmental movement. However, the book and movement's mainstream audience, white middle-class communities, responded with a strong 'not in my backyard' (NIMBY) approach when it came to the siting of environmental hazards that would impact public health and property (Bullard and

Wright 1987; Taylor 2002; Saha and Mohai 2005). As white middle-class populations had the voice and power to resist environmental threats in their own communities, communities of color and low-income communities were seen as the path of least resistance, leading to disproportionate locations of toxic facilities in these communities (Bullard and Wright 1987, Pastor et al 2001, Bullard and Johnson 2000; Saha and Mohai 2005).

Two decades later, a 1982 community battle against the siting of a controversial polychlorinated biphenyl (PCB) landfill in North Carolina drew attention to the location of hazardous facilities in relation to population demographics. The location of this particular hazardous waste site was set in a predominately-black community of Warren County, mobilizing hundreds of African Americans in protest and resulting in 500 arrests. Photos of the protest spread across the nation, showing black activists lying across a rural road blocking a dump truck filled with the PCB-laced dirt, which brought wider awareness to the issue throughout the U.S. (Bullard 1990; Taylor 2009).

The event prompted a movement of scholarly research and activism on environmental justice, establishing its existence nationwide with three major studies providing a foundation for the field of study. The first study was conducted in 1983, when the U.S. General Accounting Office (GAO) published a report examining the relationship between the location of hazardous waste landfill sites and the racial and socioeconomic status of surrounding communities. The researchers compiled zip code level population information around the location of four hazardous waste facilities in EPA Region IV (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, and Tennessee). The report found that in three of the four areas containing hazardous waste facilities, the majority of the population was black (GAO 1983).

Similarly, a second study was published in 1987, sponsored by the United Church of Christ's (UCC) Commission for Racial Justice. This study compared the racial and socioeconomic status of populations in zip codes containing hazardous waste TSDFs to all of the zip codes in the U.S. that did not contain facilities. The report found that zip codes with at least one commercial TSDF had twice as many people of color on average than in areas without a TSDF. They also found that the racial disparities were statistically more significant than socioeconomic variables, allowing the UCC to conclude that race was the most significant factor when determining the location of hazardous waste TSDFs (Chavis and Lee 1987).

The third foundational study, conducted by Mohai and Bryant (1992) examined households within 1.5-miles of 15 commercial waste disposal sites throughout three counties in the Detroit, Michigan area. The study found that the proportion of African Americans living within 1.0-miles of a TSDF was significantly higher than both the proportion living between 1.0-mile and 1.5-miles and greater than those living beyond 1.5-miles (48%, 39%, and 18%, respectively). Similar to the UCC study, they found racial disparities were significantly greater than socioeconomic disparities at each distance (Mohai and Bryant 1992). This study also provided the first systematic review of existing empirical environmental justice studies which verified the 1987 UCC report. Collectively, these studies laid a foundation for more focused research, establishing a scholarly field, social movement, and policy on environmental justice.

Longitudinal Studies

Following aforementioned environmental justice studies, numerous scholars published reports that support the claim that hazardous waste sites, higher per capita criteria pollutant emissions, and toxic air emission facilities are disproportionately located in areas with higher percentages of marginalized groups, most prominently in black communities (GAO 1983; Bullard 1983; Chavis and Lee 1987; Bryant and Mohai 1992; Carson, Jeon, and McCubbin 1997; Ash and Fetter 2004; Pastor, Morello-Frosch, and Sadd 2005; Ringquist 2005; Mohai et al. 2009; and Zwickl, Ash, and Boyce 2014). Together, these studies often confirm the existence of socioeconomic and racial disparities in a variety of environmental hazards, firmly establishing patterns of inequality in environmental justice literature (Mohai and Saha 2015a). Yet, most existing studies only consider current distributions of socio-spatial environmental inequality, conducted via cross-sectional analyses at one point in time, leaving out discussion of when and how these injustices began to occur (Mohai and Saha 2015a).

Although the number is significantly limited compared to those that evaluate current disparities, there are a handful of studies that consider the demographic composition of communities surrounding environmental hazards at the time of siting and demographic changes over time. Primarily, there are two general hypotheses for the processes by which these disparities occur: (1) at the *time of siting*: environmental hazards have been disproportionately placed near low income communities and/or communities of color or (2) *demographic changes after the time* *of siting* have led to disproportionately high percentages of low-income populations and people of color in the communities where siting occurred (Mohai and Saha 2015a). These two processes are not mutually exclusive and have both been found to have contributed to racial and socioeconomic disparities in the location of hazardous waste TSDF sites (Mohai and Saha 2015b).

Methodological Differences

Many early longitudinal environmental justice studies found little or unclear patterns for the siting of such facilities (Been 1994; Hurley 1997; Hamilton 1993 Hamilton 1995; Been and Gupta 1997; Oakes et al. 1996; Anderson, Anderson, Oakes 1994). However, Mohai and Saha (2015a) found that these inconclusive results were likely due the past reliance on the unit-hazard coincidence method of conducting environmental disparity studies rather than distance-based methods. When using the unit-hazard coincidence method, researchers identified units (for example, counties, zip code boundaries, or Census tracts) that contained hazards, and compared population demographics to units that did not contain the hazards (GAO 1983; Chavis and Lee 1987; Anderton et al. 1994). Mohai (1995) argued that this method is inaccurate for identifying the affected population, as it does not take into account the exact location of each facility nor draw consistent geographic units around the facilities. For example, the method does not address the fact that tracts and other commonly used geographic units such as zip code areas vary greatly in area such that, in the case of very large units for example, populations living considerable distances away from a TSDF that may not be affected by it, are counted among the affected population. This method also assumes the affected population is equally and exclusively within the borders of the facility, when in reality a facility may be posing a greater burden for populations in neighboring tracts than that of their own (Mohai 1995). For example, Mohai and Saha (2006) found that 71% of all hazardous waste TSDFs in the U.S. are within 0.5-miles of the boundaries of their host tracts while 49% are within 0.25 mile.

In order to find an approach that could more accurately count people living in the communities surrounding environmental burdens, Mohai and Saha (2006) highlighted three distance-based methods that use the precise locations of facilities and assess the demographic characteristics of all the units within specified, uniform distances, not necessarily just in the host unit.

The first, the 50% areal containment method (Figure 1), averages or aggregates the demographic characteristics of predefined geographic units (zip codes, Census tracts, etc.) that intersect a specified distance generated by a circle centered at the location of an environmental hazard of interest. The reconstituted host neighborhood thus only includes units in which at least 50% of the area is intersected with the distance circle, producing an end result that looks like a "circle with rough edges" (Mohai and Saha 2006, pp. 387).

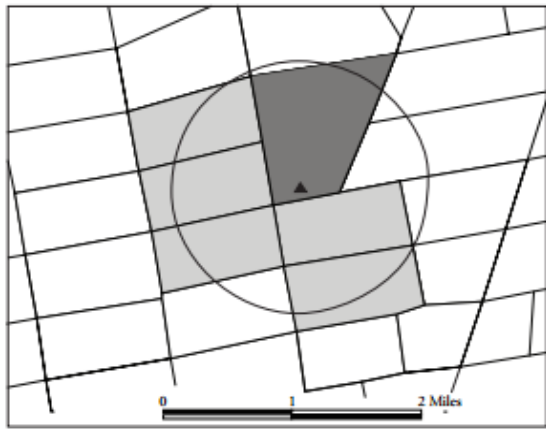

Figure 1. 50% Areal Containment Method.

This figure depicts the host tract in dark grey, which would be used in the classic, unit-hazard approach, and the tracts that are 50% contained by the 1-mile radius in light gray, which would constitute the host neighborhood used in the 50% areal containment method. (Mohai and Saha 2006).

Similarly, the boundary intersection method uses the same approach as 50% areal containment, but includes demographic characteristics from *all* of the predefined geographic units that intersect with the distance circle, regardless of whether or not more than 50% of the area is intersected. However, this may result in areas that are far from the facility being included (Mohai and Saha 2006).

Mohai and Saha (2006, 2007) argue that the most accurate and reliable approach is the areal apportionment method (Figure 2). Demographic characteristics of all predefined units that are contained or intersected by the distance circle are aggregated; however, first each unit's population is weighted by the proportion of the area of the unit that is captured by the circle. Unlike the previous methods, these results form a perfect circle from which distance was specified. It should be noted, however that this method is still slightly flawed, as it assumes population is distributed uniformly throughout the geographic units, which is most likely not how the population is distributed. However, such an assumption is also made when applying the unit-hazard coincidence method and whenever Census data are reported and analyzed by geographic units, regardless of the units' size.

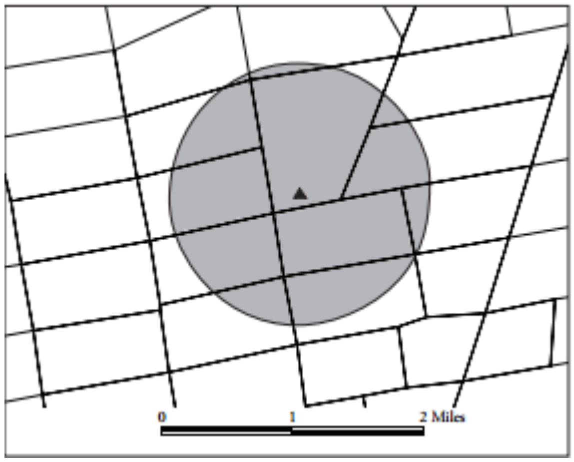

Figure 2. Areal Apportionment Method.

Figure 2 depicts the output of areal apportionment method using a 1.0-mile radius (Mohai and Saha 2006).

In order to test the differences in results between approaches, Mohai and Saha (2006) applied these approaches using TSDF locations in the U.S. identified in a prior national study (Been 1995), 1990 Census demographics, and 1.0, 2.0, and 3.0-mile circular buffers. Using the same data set, they compared their distance-based approaches to the unit-hazard approach and found widely varying results. For example, results indicated the TDSFs' surrounding communities were 42% people of color when distance-based approaches were applied, yet TDSF host communities were only 25% people of color when the unit-hazard approach was applied. They also found that results using distance-based approaches were more likely than the unit-hazard approach to lead to statistically significant results (Mohai and Saha 2006). This supports their argument that the variation in findings across the earlier environmental justice quantitative studies can be attributed to variation in methods.

As mentioned previously, differences in methodology may also account for the varying results of the few longitudinal environmental justice studies that have been conducted. For example, studies by Been and Gupta (1997) and Oakes et al. (1996), which found little or no evidence for disparate siting for African American populations, used the unit-hazard approach, while studies by Pastor et al. (2001), Saha and Mohai (2005) and Mohai and Saha (2015b), which found such evidence to be significant, used distance-based approaches. Their results are elaborated on below.

Sub-National Studies

Several studies attempt to evaluate the siting of hazardous waste facilities at a subnational level. Pastor et al. (2001) considered hazardous waste TSDFs in Los Angeles County using 1970-1990 Census tracts and the distance-based method with 0.25 and 1.0-mile buffers. Their results supported disproportionate siting rather than post-siting demographic changes. In particular, they found that neighborhood-level ethnic/racial transition was an important predictor of siting. Ethnic/racial transition or "churning" refers to the change in minority population within an area from one group to another, in this case, African American to Latino and vice versa. Pastor et al. were able to evaluate racial transition by studying race/ethnic groups such as Latino and African American separately, as opposed to placing all minority groups together, which was the dominant metric at the time. For example, a neighborhood's "minority population" may remain the same, but reflect a 40% increase in Latinos that is matched by a 40% decrease in African Americans over the study time period. They found evidence that "ethnic churning", along with disproportionately high minority populations, attracted facility siting, supporting the hypothesis that racial/ethnic transitions can also make areas politically weak and vulnerable to siting (Pastor et al. 2001)

Similarly, Hipp and Lakon (2010) evaluated a) if relative proximity to Toxic Release Inventory (TRI) Facilities (what they refer to as "toxic waste sites") were associated with differences in race/ethnicity and educational attainment for six highly populated, diverse counties in Southern California over a 10-year time period between 1990 and 2000; and b) if disparities across racial/ethnic and educational attainment groups differed when considering the toxicity weights of the various toxic emissions. The distance from these counties to the U.S/Mexico border allowed for a unique emphasis on Latino and immigrant populations.

Using distance-based methods, Hipp and Lakon (2010) assessed the impact of TRI facilities by multiplying the pounds of toxic emissions released by the measure of its toxicity and apportioned this value to a 1.0-mile buffer around each site. In particular, they used latent trajectory models to create quadratic equations that assessed tracts' (and the tracts' subsequent racial/ethnic socioeconomic characteristics) relative proximity to toxic waste. A tract's 'proximity to toxic waste' was based on whether or not the tract was within 1.0-miles of a facility emitting toxic waste and the amount and relative toxicity of the toxic waste emitted based on harm for human health.

Holding all other measures constant, their results showed increasing proximity to "toxic waste facilities" for African-Americans over the 10-year time period, meaning that over time, higher proportions of African-American populations were more likely to be within 1.0-miles of facilities emitting toxic waste. On average, tracts with higher percentages of African-Americans than the average tract were 3.2% more likely to be within 1.0-miles of facilities, yet an even stronger effect was found for Latinos and Asians. A tract with 15% more Latinos than the average tract was exposed to 84% more toxic waste than an average tract between 1990 and 2000, whereas a tract with more Asians than the average tract was exposed to about 34% more toxic waste over this time period. Another key finding was that tracts with many highly educated residents had particularly low, and declining, proximity to toxic waste states over the 10-year time periods (Hipp and Lakon 2010).

Also using distance-based methods, Saha and Mohai (2005) evaluated the siting of hazardous waste facilities in Michigan from 1950 to 1990. They found significant racial, socioeconomic, and housing disparities for facilities sited after 1970 (but not prior) and were the first paper to discuss the importance of historical context in conducting empirical environmental justice analyses and anticipating patterns of racial and socioeconomic disparities at the time of siting (elaborated further beginning on page 18).

Yielding significant results, each of these studies highlight the need for further longitudinal research exploring the relationship between facility siting and population demographics on a larger scale to see if results were generalizable to other communities across the nation. Likewise, following the example of Hipp and Lakon (2010) further studies should consider not only proximity to hazardous facilities, but relative toxicity of such emissions and different social dimensions such as immigrant status.

National Level Studies

National-level longitudinal studies of TDSF siting have also been conducted, but these too have been few in number. Oakes et al. (1996) conducted the first national study evaluating disparities in the siting of hazardous waste TSDFs and post-siting change. They examined disparate siting and post-siting demographic change in the period between 1970 and 1990. The researchers employed a unit-hazard approach and found no significant evidence of either disparate siting or post-siting demographic change. They suggest that demographic characteristics in communities are best explained by general population trends. Similarly, Hunter et al. (2003) conducted a national study evaluating post-siting demographic change based on county-level race data and found no significant evidence for post-siting racial migration changes associated with high incidents of environmental hazards.

Been and Gupta (1997) also examined disparate siting and post-siting demographic change using the unit-hazard approach, looking at Census tracts in the period between 1970 and 1994. When comparing the mean percentage of African-Americans, Hispanics, and white populations in host tracts and non-host tracts, descriptive results indicated no evidence for hazardous waste TSDFs being disproportionately sited in African American communities during any of the three studied decades. There was statistically significant evidence that the percentage of Hispanics in a tract was correlated with the probability that the tract hosted a facility between 1970 and 1979.

However, multivariate analysis (logit estimations) concluded that both racial/ethnic variables, percentage of African-Americans and the percentage of Hispanics, were statistically significant predictors of facility siting from 1970 to 1979 once other socioeconomic variables were controlled. Only the Hispanic variable remained as a statistically significant predictor from 1980 to 1989 (Been and Gupta 1997). The African American percentage variable became significant after multivariate controls were applied, possibly suggesting that African American disparities were not large to begin with, and that TSDFs were slightly more likely to be sited where wealthier, rather than poorer, African Americans lived. In particular, they found that Hispanics, rather than African Americans, were most at risk from the siting process and that working class and lower middle class communities, rather than very poor communities, bear a disproportionately high number of facilities (Been and Gupta 1997).

More recently, Mohai and Saha (2015b) conducted the first national-level environmental justice study that employed a longitudinal analysis using a distance-based approach. Their purposes were: (1) to determine whether disparate siting, post-siting changes, or a combination of both were responsible for present day disparities; (2) to test related hypotheses about the economic, socio-political, and discriminatory factors thought to drive disparities; and (3) to determine whether the application of a distance-based approach explains the contradicting findings of previous studies.

In this study, Mohai and Saha (2015b) used the national database of commercial hazardous waste TSDFs sited from 1966 to 1995, the same facilities that were employed in the 2007 UCC study, *Toxic Wastes and Race at Twenty* (Bullard, Mohai, Saha, and Wright 2007). With this database, Mohai and Saha (2015b) examined the demographic composition of host neighborhoods at the time of siting and the changes that have occurred since siting. Their analysis employed both the areal apportionment and 50% areal containment methods, the exact location of the facilities, a 3.0 km radius around each community, and decennial Census data for the periods between 1970 and 2000. They found strong evidence of disparate siting for facilities in all time periods, as well as evidence of post-siting demographic changes. However, they also found that most demographic changes were a continuation of changes that already began occurring *prior* to siting. This suggests that neighborhoods in transition attract hazardous facilities, not that the facilities themselves attract low-income people and people of color (Mohai and Saha 2015b).

Through the aforementioned studies and results, it is clear that recognizing the differences of distance-based methods versus the unit-hazard coincidence approach is critical toward understanding why past longitudinal environmental justice studies have produced inconclusive findings. The studies using the unit-hazard coincidence method have shown virtually no patterns of any kind while distance-based studies have produced clearer patterns of inequality (Oakes et al. 1996; Been and Gupta 1997; Saha and Mohai 2005; Hipp and Lakon 2010; Pastor et al. 2001; Mohai and Saha 2015b). The distance-based studies are the first to provide statistically significant evidence supporting the disparate siting hypothesis, and Mohai and Saha (2015b) was the first and only longitudinal study to date using such methods that has been national in scope. Therefore, this study employs distance-based methods to examine a second national set of environmental hazards, CFPPs, and will thus be only the second national-level longitudinal environmental justice study to use such methods. It is also only the second longitudinal environmental justice (after Saha and Mohai 2005) to go back as far as 1945 and the first national-level study to do so. The results of this study are an important contribution to environmental justice scholarship, answering whether similar patterns can be found for CFFPs as have been found for TSDFs by Mohai and Saha. Although much of environmental justice literature has focused on TSDFs, expanding the understanding of siting to other types of polluting facilities is important to recognizing inequality and improving quality of life, policy, and health in environmental justice communities more broadly. The impact of CFPPs, in particular, is elaborated on in Chapter 3.

Siting Theories

In addition to their work reconciling differences in longitudinal methodologies and results, Mohai and Saha (2015a) also drew on the existing studies highlighted previously to emphasize three theoretical explanations for disparate siting and post-siting demographic change from environmental justice literature: economic, sociopolitical, and racial-discriminatory factors.

Economic (Market Dynamics) Explanations

Mohai and Saha (2015a) point out that economic explanations for disparate siting are one of the most frequently argued by environmental justice scholars. Economic reasoning involves the argument that industries seek the lowest-cost scenarios. For example, industries likely seek to site facilities where cheap land, labor pools, and transportation infrastructure are nearby (Mohai and Saha 2015b). Poor people and communities of color tend to live near those areas; therefore, such scholars argue that disparities can be explained by industries' efforts to lower the cost of business. Scholars also use economic explanations for post-siting changes, stating that the location of a hazardous facility can decrease housing values in the surrounding community, which prompts the move-out of affluent (and often white) residents, opening areas for low-income people looking for affordable housing options (Mohai and Saha 2015a).

Sociopolitical Explanations

Sociopolitical explanations of disparate siting draw on the argument that industries seek the 'path of least resistance' when choosing a location (Bullard and Wright 1987, Pastor et al 2001, Saha and Mohai 2005). This explanation is formed on the assumption that industries are aware that facility siting is unfavorable to local residents and that residents may resist or seek to prohibit new facilities from being sited in their communities. As such, scholars argue that industries intentionally site facilities in communities that are less likely to generate opposition or in communities where opposition will be ineffective because the community has few resources or little political clout. In these situations, such populations are more likely to be poor people and people of color (Mohai and Saha 2015a). Furthermore, the length of time between toxic exposure and emergence of the most serious side effects, such as cancer, is often long, resulting in what Nixon (2011) termed as 'slow violence'. This latency period may impact the time period in which public opposition and resistance occurs, as residents may realize serious health impacts after facility siting.

Likewise, in sociopolitical explanations for post-siting demographic change, scholars argue that the post-siting demographic changes created by quality of life and economic impacts could be accelerated in diverse communities and communities with lower social capitol or resources (Pastor et al 2001; Sobotta et al 2007; Mohai and Saha 2015a). Areas with few community organizations, neighborhood associations, or community leaders may be limited in their ability to participate in effective civic engagement, such as advocacy (Zahran et al 2008; Schelly and Stretesky 2009; Mohai and Saha 2015a). Often, once sited for one facility, these communities become 'sacrifice zones' that are more vulnerable to pollution, LULUs, degrading infrastructure, loss of local business, and demographic change as quality of life, property facilities, and social capital decrease over time (Lerner 2010; Elliott and Frickel 2013; Mohai and Saha 2015a).

Racial Discriminatory Explanations

There is much debate as to the existence of racial bias in the siting of hazardous facilities, but racial discriminatory explanations for disparate siting and post siting demographic change argue that economic and sociopolitical factors alone cannot explain widening socioeconomic and racial/ethnic disparities around hazardous facilities (Mohai and Saha 2015a). Some scholars argue that communities of color may disproportionately host environmental hazards due to 'side-effect discrimination' (Feagin and Feagin 1986; Mohai et al. 2009). Side-effect discrimination is defined by Feagin and Feagin (1986) as discrimination in one area of institutional actions that leads to discriminatory outcomes in another area, with or without intent to discriminate. For example, policies such as racial zoning laws and discriminatory housing practices have an impact on current locations of communities of color, particularly as they overlap with industrial zones. Elaborated on in the next section, racialized zoning, property laws, and related private practices such as racially restricted covenants were created in the mid 1990's with the intention of segregating races and placing industrial facilities in communities of color (Rabin 1989; Pulido et al. 1996; Cole and Foster 2001; Taylor 2014). These policies raise complex questions as to whether environmental disparities arise from intentional racial discrimination on a social scale, whether or not there as intent within the siting process (Mohai, Pellow, and Roberts 2009). Although those policies are now illegal and current industrial zoning does not intentionally discriminate, the outcome of such policies resulted in hazardous facilities being located in communities of color as a reflection of the social context at the time they were created (Mohai et al. 2009; Taylor 2009).

Similar explanations are in place for post-siting demographic changes. Racially discriminatory housing practices, including mortgage lending, and intentional segregation restricted the areas in which people of color were able to live, often in places with higher environmental burdens or less desirable neighborhoods. Wealthy, white populations were able to leave areas that became blighted, while people of color were forced to move in due to affordability and the restriction of loans to certain areas (Mohai and Saha 2015a; Taylor 2014).

While some racial discriminatory explanations include the act of discrimination without intent, racism should not be diluted in all hypotheses. Mills (2001) argues that many whites in the U.S. and globally view people of color as a form of 'social contamination,' linking images of people of color (specifically people of African descent) with barbarism, filth, dirt, and pollution. Such ideology makes it easier to legitimize locating hazardous facilities in communities of color. Likewise, Higgins (1994) argues that minority environments are seen as "appropriately polluted" spaces and that racial segregation facilitates environmental injustice because environmental pollution is confined to already "socially polluted" spaces (pp. 262). In these arguments, Mills and Higgins provide a framework for a broader possibility of intent and environmental racism in siting decisions.

The three above categories of explanations (economic, sociopolitical, and racial discrimination) are complex and not mutually exclusive. For example, the intent to site facilities in the 'path of least resistance' is seen as sociopolitical, but could also be economic, as to avoid costly legal battles. Likewise, if industries and the government are consciously using racial or socioeconomic characteristics of a neighborhood to make decisions about where to site hazardous facilities, motives may be economic, but also raise questions of racial discrimination and intent (Mohai et al. 2009). Although it is difficult to evaluate and determine the precise factors that result in racial and socioeconomic disparities in the distribution of environmental hazards, the above explanations help begin to identify the range of possible variables that may contribute to disparate outcomes. Knowing what explains present disparities in the distribution of hazardous sites is important to helping policymakers determine if siting processes or other related factors should be given more attention (Mohai et al. 2009).

The Environmental Movement, NIMBYism, and Historical Discrimination

Although emphasized in siting theories, few longitudinal environmental justice studies take into account historical context when evaluating the presence of disparate siting. Saha and Mohai (2005) are the first and only researchers to test whether historical growth of public environmental concern and changes in environmental policies resulted in increasing environmental inequalities in hazardous waste TSDF siting. They point out that throughout the 1960's and early 1970's, growing public environmental concern on air and water issues likely had an impact on where facilities were sited. In particular, highly visible events, such as the Three-Mile Island nuclear incident and the Love Canal Story, both in the late 1970's, fueled public opposition to environmental hazards (Saha and Mohai 2005; Szaz 1994; Kasperson 1986). It is believed that public concern contributed to the widespread growth of grassroots community organizing during this time period. However, rather than seeking protections from hazardous facilities for all peoples, these actions often focused on opposition at the local level. Organizers worked toward preventing siting exclusively within their own communities, a phenomenon recognized as the aforementioned Not-In-My-Backyard (NIMBY) syndrome (Saha and Mohai 2005). While the role of this public opposition in successfully preventing new facility siting is well documented (O'Hare, Bacow, and Sanderson 1983; Rabe 1994), much of this opposition occurred during the height of the civil rights movement, when communities of color were focused on other issues (Taylor 2009). As mentioned previously, the environmental justice movement did not develop fully until the 1990s, therefore it is likely that siting in low-income communities of color proliferated through the 1970's and 1980's (Bullard and Wright 1987; Taylor 2000).

In their study, Saha and Mohai (2005) found evidence to support that this historical context influenced the siting of hazardous waste TSDFs in Michigan. TSDF host communities prior to the environmental movement had good housing and employment conditions relative to non-host neighborhoods, while facilities sited in the 1970's and 1980's were located in neighborhoods with severe income and poverty disparities, low housing demand, and high rates of housing decline. Likewise, host communities had significant racial disparities when compared to non-host communities, made up of predominately black populations from the late 1970's onward. However, there was a slight decrease in the concentration of racial disparities in the 1980's, providing evidence consistent with the influence of the emergence of the environmental justice movement.

Saha and Mohai (2005)'s study also touched on the stark segregation in Detroit as a potential factor for influencing siting. For example, the highly segregated central city and smaller African American neighborhoods appeared to have been targeted for new TSDFs in the 1980's. New facilities were sited in areas with aging and inferior housing as Detroit experience both de-industrialization and white flight, which further concentrated people of color and the poor in the central city (Mohai and Saha 2005; Surgue 1996; Wilson 1992). The process of transitioning neighborhoods reduced social cohesion and political capacity, creating demographic instability that could have made such areas particularly susceptible to new facility sittings (Saha and Mohai 2005; Pastor et al. 2001). This is consistent with the findings of many other scholars that documented examples of how racial housing segregation and discrimination practices, disinvestment, economic decline, uneven redevelopment, and industrial zoning have concentrated people of color and the poor in communities hosting environmental hazards in cities across the nation (Boone and Modarres 1999; Hersh 1995; Hurley 1995; Pulido et al. 1996; Montrie 2005; Pellow 2002; Szasz and Meuser 2000; Taylor 2014). Many of these factors are a product of government institutions, causing scholars to link disparate siting to the aforementioned 'side effect' or indirect institutional discrimination (Saha and Mohai 2005; Taylor 2014).

In fact, indirect and direct examples of both institutions and industries affecting which populations are closest to polluting facilities pre-exists the 1970's and 1980's. In the early twentieth century, prior to heightened environmental awareness, industrial facilities often were in company towns laid out to reflect hierarchy within the company. For example, Gary, Indiana, initially started as a company town, in which the best houses were reserved for the managers and supervisors of the local steel mill. These high-paid employees were all of western European ancestry, and their houses were built close to the plant so they could easily walk to work. At the time, the health impacts of pollution were not known, so the proximity to the plant was seen as a luxury. Low-level workers were built homes farther from the plant, so that racial and ethnic minorities lived at the fringe of the cities. This internal hierarchy could help to explain the lack of evidence for disparate siting in the early 1990's and supports the notions that increased environmental awareness and suburbanization contributed to the disproportionate burden of environmental hazards in communities of color and low income communities. Throughout the late 1950's and early 1960's, better housing opportunities and new transportation infrastructure arose in the suburbs, and White workers were able to move to all-white neighborhoods and easily commute to work, leaving poor, Blacks and other minorities with inferior housing options close to the facility (Taylor 2009).

In this time period and prior, discriminatory zoning laws and housing practices were also put in place with the intention of constraining the residential options of racial and ethnic minorities. While zoning ordinances and building codes were initially intended to separate land uses and regulate neighborhood aesthetics in the early 1990's, they evolved into a way to separate racial/ethnic minorities from White residents (Taylor 2009; Taylor 2014). White elites not only monopolized all of the best housing options in the cities, they also capitalized on new construction in the suburbs, leaving people of color with inferior housing in restricted locations. In Gary, for example, 97 percent of the city's Black population lived within a 2-mile radius downtown, nearest to pollution sources. This segregation was often facilitated by realtors and loan/insurance agents, who could control the areas in which racial minorities were shown housing options and the distribution of financial assistance (Taylor 2014). City governments also aided in segregation by denying public housing applications in traditionally white, wealthy areas (Taylor 2009).

'Redlining' was one of the most common forms of institutionalized discrimination, defined as the practice of denying or limiting loans, mortgages, or insurance in certain geographic areas based on its racial and ethnic composition. This practice created the separation between ‘white’ and ‘minority’ communities by literally tracing neighborhoods in red on maps, delineating where people were given financial assistance. The process was developed by the Home Owners Loan Corporation (HOLC) in which appraisers gathered detailed information on urban real estate to create a rating system that undervalued densely populated, minority, dilapidated, or aging neighborhoods, which sustained segregation in many cities (Squires 2011). As shown in a 1939 redlining map of South Chicago (see Figure 3), areas were ranked in four categories from best to worst: green, blue, yellow, and red.

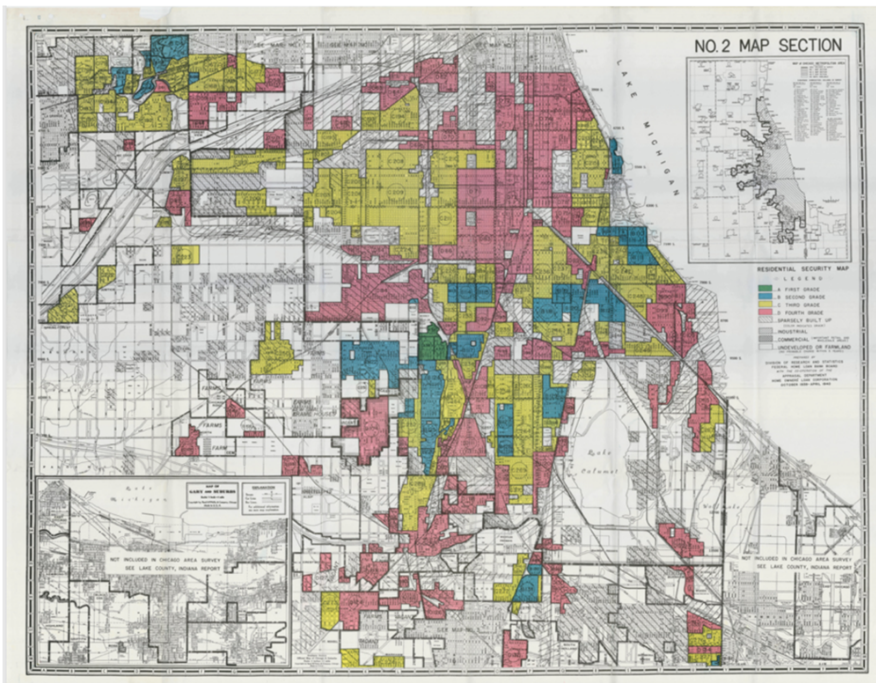

Figure 3. 1939 Redlining Map of South Chicago.
Figure 3 is a 1939 HOLC ‘Residential Security Map’ of South Chicago depicting discrimination against populations of color via the practice of ‘redlining’. Source: Nelson et al. 2017.

These zoning laws and discriminatory practices did, and still have, far-reaching influence on where LULUs, and the environmental health effects that arise from such uses, are located (Cole and Foster 2001; Bullard and Wright 1987; Maantay 2002; Taylor 2014). Legalized racial zoning and the consequences of the environmental movement and NYMBY phenomena created confounding factors by which poor, communities of color were likely targeted for LULU siting. While the Fair Housing Act of 1968 ended housing discrimination legally, the segregated neighborhoods created by such policies still linger today (Taylor 2014). By considering the importance of historical context, this study will test whether Saha and Mohai (2005)’s hypotheses for hazardous waste TSDFs can be generalized to CFPPs, and if, for the first-time, this context impacts siting on a national scale. This context is particularly important for CFPPs, as they are known for emitting large amounts of highly toxic pollution, which has a drastic effect on human health and well-being (Keating 2001). These health impacts, along with siting and environmental regulations that influence specific CFPP emissions and locations, are discussed in the next chapter.

<u>CHAPTER 3:</u> The Regulation, Impact, & Distribution of Coal-Fired Power Plants

The historical significance of the environmental movement also extends to the policies that were created from related public concern. As a result of growing environmental awareness, significant federal environmental regulations were established that impacted the pollution and public awareness of health impacts from CFPPs. A better context of these federal and local public policies lends further insight on the factors potentially influencing the distribution of CFPPs. Likewise, a greater understanding of the human health impacts of CFPPs can help establish the importance of assessing which populations were most vulnerable to emissions-related burdens.

Federal Environmental Regulations

The Clean Air Act

Prior to the creation of the Clean Air Act (CAA) in 1970, the regulation of air pollution, among most other environmental issues, was delegated to the states. Throughout the 1950s and 1960s, air pollution became a public concern as smog overwhelmed major cities such as Donora, PA, Los Angeles, CA, and New York City, NY. Hundreds of deaths evoked major public outcry towards state inaction and lack of pollution control. Congress enacted the Air Pollution Control Act in 1955 with the purpose of encouraging states to create regulation with financial aid and research; however, this effort proved unsuccessful (Salzman and Thompson 2010).

In 1970, Congress passed the CAA amendments, which created the first strong federal air pollution control law. This act set National Ambient Air Quality Standards (NAAQS) for the six criteria pollutants (carbon monoxide, lead, ground-level ozone, nitrogen dioxide, particulate matter, and sulfur dioxide), as well as standards for auto emissions and new stationary sources (Lazarus and Houck 2005). The NAAQS consist of primary standards that protect human health, and secondary standards that protect public welfare such as domestic animals, wildlife, water, and aesthetics. Every five years, the Environmental Protection Agency (EPA) is required to consider new standards, as well as review and correct existing ones. For example, in 1990, the CAA was amended to set new goals for the achievement of NAAQs. These included a requirement of technology-based standards for major sources (such as CFPPs) to reduce sulfur dioxide emissions that create acid rain, which occurs when sulfur dioxide and nitrogen oxide emissions are transformed in the atmosphere and return to the earth in rain, fog, or snow (EPA 2017 a,c). Now, decades later, the amount of many major air pollutants in the atmosphere has decreased, despite dramatically increased economic activity. In practice, these standards reap great benefits for human health and the environment, but they are also highly influenced by political and economic costs (Salzman and Thompson 2010).

While these efforts were substantial and yielded significant results, there is a loophole in the CAA that has allowed many CFPPs in low-income communities of color to continue generating pollution beyond these standards (Salzman and Thompson 2010). Plants built prior to the CAA were grandfathered in – exempt from modern environmental requirements under the assumption that they would end up closing not long after the regulations passed due to old age. If the plants did not undergo major modifications, owners were not required to add any modern pollution controls that would protect the surrounding communities. In reality, many old plants continue operating beyond their life expectancy, allowing them to function at a much cheaper rate than new, more efficient facilities. As a result, CFPPs contracted prior to 1967 have continued to avoid stricter emissions standards and emit four to ten times more sulfur dioxide and nitrogen oxide per hour than their newer counterparts (Salzman and Thompson 2010). These specifications allowed many older CFPPs, like the Fisk Generating Station in Chicago, to run 100-year-old stacks with no major pollution controls (Henderson 2009). According to data from the EPA Emissions & Generation dataset (2012) and methods elaborated on later in this study, as of 2012, there were 192 plants operating in the U.S. that fell under this grandfathering exemption, meaning that they were built or contracted prior to 1967.

Power Plant Siting

Parallel to the environmental movement and subsequent regulation, government regulation of power plant siting decisions received considerable attention in the early 1970's. Increased environmental awareness, along with the National Environmental Policy Act in 1969, the first Earth Day in 1970, and federal air and water pollution, such as the aforementioned Clean Air Act, brought controversy and attention to the construction of Calverts Cliffs nuclear power plant on Chesapeake Bay and power plant siting more broadly. Repeated "brownouts" (electric shortages) across the nation in the summer of 1970 also renewed public interest in federal energy "reliability" and siting legislation. Throughout the next few years, several Congressional hearings were held on competing proposals for expanded federal siting authority, however none of them were enacted (Hamilton 1979).

At the same time, state legislatures, fearful of lengthy delays from siting controversies and the possibility of increased federal oversight, began to enact their own siting regulations designed to expedite the siting process, rather than adhere to environmental protections (Hamilton 1979). Many siting provisions for power plants were dictated primarily by proximity to load centers (where power was distributed), land requirements, fuel supply, and transportation access (Tarlek et al. 1972); however, there was, and still is, no "typical" approach across state siting legislation (Tierney 2007). Some state laws treat energy facilities no differently than the siting of other large infrastructure built by private developers, some states enacted laws only after a big fight over a proposed power plant, other states have included "energy facility siting" in the legislative process to take land for a public purpose, while several states have no siting laws all together (Tierney 2007).

At first, utility companies simply needed to persuade the state utility commission that a new power plant was needed and that it was economically sound, and permission to build the plant would be granted. Other permits would be acquired as the utility acquired a facility site and began construction. However, since the early 1980's, several obstacles have been put in place that must be carefully considered in facility siting, including environmental regulation at the state and local level. State agencies have been created to monitor environmental quality and issue permits for industrial activities, however the effectiveness of these facilities have been questioned due to lack of resources and capacities in many states.

Within the bounds of existing laws or regulation, private energy corporations generally dictate siting locations using their own criteria. Public institutions at the federal, state, and local level are able to grant or deny permits and/or suggest design modifications, but they usually are not directly involved in the siting process (Calzonetti et al. 1980). Many state policies operate on a permit-by-permit basis, and are often overlapping or uncoordinated within agencies and levels of government. Private interest groups take part in the siting process further along, creating confounding problems for communities who attempt to get involved. Throughout the process, there is often little effort to consider and balance the continued interests of varying groups, from environmental advocates, to the industries, and local residents (Calzonetti et al. 1980). These considerations, or lack thereof, may greatly impact the community demographics in areas sited for CFPPs and other industrial facilities, and in particular, highlight the relevance of the aforementioned sociopolitical explanations in siting facilities in the 'path of least resistance' that often results in siting in communities of color and low-income neighborhoods that have less social capital or resources to fight industries.

There is also evidence that U.S.'s efforts to rely on domestic energy sources, along with the surplus of natural resources such as coal in the western states, caused many utilities operating in the east to propose development in the West. Large-scale energy facilities started to be sited in small towns and rural areas, prompting new socioeconomic effects (Calzonetti et al. 1980). For example, in the 1980's, CFPPs requested 2,500 – 5,000 employees, yet were sited in towns with 10,000 people. The new CFPPs, and associated population demands, created strains on public and private services, from housing shortages, infrastructure issues, to medical care, known as "boomtown" problems (Armbrust 1977; Gilmore and Duff 1975). Plants in rural areas were also often sited right outside of town boundaries in order to avoid paying direct taxes to their host municipalities, creating further financial crises. In Colstrip, Montana, developers attempted to avoid financial and housing impacts by building a new town to serve a coal mine and power plant workers, similar to the urban company towns discussed in Chapter 2 (Myhra 1975). However, nearby towns still experienced the increased population and socioeconomic problems (Gold 1974). Further, while cities quickly adopted zoning policies and local land use laws that were sometimes racialized (discussed in in Chapter 2 above beginning on page 17) (Taylor 2009), such local ordinances are less likely to exist in the West and many rural areas. Therefore, historically, such local policies, often construed along racial lines, may have only been a factor in mostly urban areas.

This is important as the shift to siting energy facilities in rural communities through the 1980's onward may also be reflected by a shift in demographics in host communities. The transition to state siting policies in the 1970's, along with increased environmental regulation, and a shift from urban to rural host communities all have a potential impact on the populations nearest CFPPs. By assessing the racial and socioeconomic disparities in CFPP siting over time, the impact of such regulations and strategies can be seen. Special attention to these populations is important, as CFPPs, even with environmental regulation and consideration, pose substantial threats to the health of people in nearby communities, discussed in the section below.

The Impact of CFPPs

Despite significant air pollution regulation and increased attention to siting decisions throughout the last several decades, industrial facilities still pose a significant burden on human and environmental health. In particular, the impact of CFPP emissions have been the focus of extensive public health analyses (Schneider 2010; Levy et al. 2002; Keating 2001; National Research Council 2010).

Health Risks

The environmental and health risks posed by CFPPs have been thoroughly established in the literature. Research based on the Toxics Release Inventory has noted that the electric power industry is the largest toxics polluter in the U.S., of which coal is the most toxic when compared to other fuels (National Environmental Trust 2000). Each stage of coal production generates pollution. In particular, the process of burning coal for energy produces greenhouse gases and other harmful pollutants such as carbon dioxide, mercury, sulfur dioxide (SO_2), nitrogen dioxide (NO_x), and particulate matter. These emissions are released at every stage of production: mining, transportation, clearing, and burning (Wilson et al. 2011).

In the final stage of production, toxic chemicals are released, having an adverse impact on the surrounding air, water, and land. Many of the pollutants pose a threat to human health; individual pollutants are known to cause cancer, impair reproduction and the development of children, damage nervous and immune systems, and cause respiratory conditions such as asthma (Keating 2001). Fine particle pollution is believed to be the most dangerous pollutant because particles are small enough to bypass the body's defense mechanisms and accumulate inside a person's lungs. In coal-fired energy production, some particulate matter pollution is released and additional particulate matter forms when SO_2 and NO_x react in the atmosphere. Inhaling this type of pollution can cause a variety of health effects, from asthma attacks and lung tissue damage to strokes, heart attacks, and premature death (Schneider 2010).

Significant health impacts also are associated with sulfur dioxide, nitrogen oxides, and mercury emissions from CFPPs. While short-term exposures to sulfur dioxide can harm the respiratory system and make breathing difficult (EPA 2016b), long-term exposure and exposures to high levels of sulfur dioxide can be life threatening. For example, copper mine workers who were present during an explosion experienced burning of the nose and throat, breathing difficulties, and severe airway obstructions. Likewise, lung function changes were recorded in industry workers who were exposed to low levels of sulfur dioxide over several decades (CDC 1999). Asthmatics, children, and the elderly are particularly vulnerable to these affects (EPA 2016b).

Nitrogen oxides have similar effects on the respiratory system. Short-term exposures can aggravate asthma and lead to respiratory conditions such as coughing, wheezing, or difficulty breathing, requiring hospital admissions and visits to emergency rooms. Long-term exposures lead to the development of asthma and other respiratory infections. Like sulfur dioxide, children, the elderly, and people with asthma are at greater risk of these health effects (EPA 2016a).

Different from other emissions, populations are exposed to mercury by consuming fish that have bioaccumulated mercury. This is particularly harmful for youth, infants, and fetus, damaging developing nervous systems. Until the Clean Air Mercury Rule in 2005, CFPPs were the only remaining, unregulated major source of industrial mercury pollution in the U.S. Local emissions from CFPPs have been a particular concern for mercury exposure, known to create "hot spots" that prompted stricter regulation and technology requirements (Charnley 2006).

Another threat to human health, coal ash – a byproduct of burning coal – has recently been found to be more radioactive than waste produced by nuclear power plants (Hvistendahl 2007). In particular, the fly ash emitted from CFPPs was found to carry 100 times more radiation into the environment than a nuclear power plant producing equivalent amounts of energy (McBride et al. 1978). Uranium and thorium, coal's radioactive elements, only occur in small amounts in coal's natural state, but are concentrated up to 10 times higher than original levels when burned into ash. This ash leaches into soil and surrounding water and could be ingested by people living near plants (Hvistendahl 2007). However, previously mentioned emissions such as sulfur dioxide and nitrous oxides post greater risks than radiation (McBride et al. 1978).

Placing all of these health impacts into perspective, the Harvard School of Public Health used an atmospheric dispersion model combined with meteorological data derived from NOAA's Rapid Update Cycle model to evaluate the particulate matter impacts from a set of nine power plants in Illinois. The results of the study attributed 41 premature deaths, 5,500 emergency room visits, and 2,800 asthma attacks each year to the emissions from the two Chicago coal-fired plants (Levy et al. 2002). The communities surrounding the plants were also found to be among the nation's most densely populated neighborhoods near CFPPs (Levy et al. 2002). In recent years, more reports were released, yielding similar results. A 2010 report by the Clean Air Task Force, a science-based non-profit founded to promote policy reducing CFPP pollution, echoed the findings of Harvard's study, linking the Chicago plants to 42 premature deaths, 66 heart attacks, over 700 asthma attacks and dozens of cases of chronic bronchitis each year (Schneider and Banks 2010). Another study by the National Research Council (2010) estimated that based on 2005 emissions, the Chicago plants caused more than $127 million in health costs annually. While these studies thoroughly addressed the dire health burden posed by CFPPs, they did not specifically evaluate which populations were facing the largest portion of such burden.

Environmental & Climate Risks

Although not the focus of this study, CFPPs also have noteworthy impacts on environmental health and climate change. Coal mining disturbs landscapes across the nation, destroying forests and creating erosion, that in most cases, cannot be reversed. Erosion, along with acid rain generated from CFPP emissions, is harmful to streams, soils, and vegetation (Greenpeace 2016). However, coal's most significant impact is through plant emissions. CFPPs are the U.S.'s largest emitter of carbon dioxide (CO_2), the primary source of climate change. In 2011, U.S. CFPPs emitted over 1.5 billion tons of CO_2 (EIA 2012). A typical CFPP generates 3.5 million tons of CO_2 a year (UCS n.d.), which is more than 700,000 cars can produce (Suzuki 2014). Some emissions can be significantly reduced with existing pollution controls; however, most U.S. CFPPs have not installed these technologies due to grandfathering clauses legislation, as mentioned previously (UCS n.d.).

These added impacts are particularly important, as we know that climate change effects will be felt first and in the most extreme in the world's most vulnerable communities. A 2014 report by the Intergovernmental Panel on Climate Change (IPCC), found that climate change is expected to decrease economic growth and create increased food security and poverty in both developed and developing countries. In particular, crop yields and rural livelihoods will be affected, through reductions in water supply, food security, and agricultural incomes. These impacts are expected to disproportionately affect poor and marginalized populations (IPCC 2014), prompting a widespread "climate justice" movement in more recent decades. The movement, a subset of the environmental justice movement, fights for increased resilience and adaptation resources, as well as stricter pollution controls in order to protect vulnerable communities (Pettit 2004; Widick 2015). However, CFPPs have also been found to have a direct impact on marginalized populations more locally, elaborated on below.

Environmental Justice and Coal-Fired Power Plants

In 2011, the National Association for the Advancement of Colored People (NAACP) released a more comprehensive, national report on the environmental justice implications of CFPPs. Researchers reviewed 378 U.S. CFPPs and evaluated how each plant affects communities of color and low-income communities. CFPPs were selected from the U.S. Energy Information Administration (EIA)'s 2008 "Existing Electric Generating Unites in the United States" (eGRID) database and were filtered so that the primary energy source was listed as coal and the plant capacity was greater than 100 megawatts (MW). For each plant, the U.S. EPA's Clean Air Markets Program database was used to assess SO_2 and NO_x emissions, and Free Demographics, an online geographic information tool, was accessed to find 2000 Census block-level demographic data. The 50% areal containment method was used find the total population, per capita income, and percentage of people of color population with a 3.0-mile radius of each plant (Wilson et al. 2011). Following Ash et al. (2009) "percentage of people of color" was defined as the sum of the percentages of people who identified as "American Indian or Alaska Native Alone," "Asian Alone," "Black Alone," "Native Hawaiian and Other Pacific Islander Alone," and "Hispanic or Latino" in the Census. Free Demographics, the online geographic information tool used by the researchers, does not include a variable for "White Non-Hispanic"; therefore, their process did not separate Hispanics from the count of Whites and it is possible that they underestimated the degree of racial/ethnic disparities between areas within 3.0-miles of CFPPs and beyond 3.0-mile of CFPPs (Wilson et al. 2011).

Overall, the study indicated that nearly six million people live within 3.0-miles of CFPPs, and that the plants are disproportionately located where people of color and low-income people are concentrated. In particular, they found that the average per capita income for people living within three miles of CFPPs was $18,400, significantly lower than the national average of $21,587. Additionally, the researchers found that 39% of the population living within 3.0-miles of CFPPs were people of color, while people of color made up only 36% of the total U.S. population in the 2000 Census.

Wilson et al. (2011) also ranked the CFPPs and parent companies based on ‘environmental justice performance,’ which was a score calculated by the product of ‘exposure score’ and ‘demographic score.’ The ‘exposure score’ was calculated by multiplying the plant’s sulfur dioxide emissions in tons, its nitrogen oxide emissions in tons, and the cube of the total population living within 3.0-miles. The ‘demographic score’ was calculated by multiplying the percentage of people of color living within 3.0-miles by the average per capita income of populations living within 3.0-miles. CFPPs were ranked 1-378 and companies were ranked 1-59 with smaller numbers indicating greater emissions and impact on environmental justice communities. Through this ranking, they found that 7 of the 12 host communities with the highest ranked CFPPs were located in the Midwest. They found that 39 of the 75 highest ranked CFPPs were owned by only 12 companies; those companies also owned the 12 highest ranked CFPPs in the study (Wilson et al. 2011).

Wilson et al. (2011) is the first and, until now, only national study evaluating present-day demographic disparities in the location of CFPPs that I am aware of. The present study seeks to expand on the NAACP study by conducting the first national-level longitudinal study of racial and socioeconomic disparities in the siting of CFPPs to determine whether the present-day disparities are the result of a historical pattern of disparate siting of CFPPs *at the time of siting*. By employing distance-based methods to achieve these ends, it is also only the second national-level longitudinal environmental justice study to employ such methods.

Existing Research Gaps

Although it is clear from existing literature that CFPPs, specifically air pollution generated by the burning of coal, pose serious risks to human and environmental health (Keating 2001), few studies employ distance-based methods to evaluate which populations are most affected by such burdens.

Based on the findings of this literature review, this research attempts to evaluate the demographic characteristics in CFPP host communities (using 3.0-mile radius around CFPPs) at the time of siting and in 2010 (the most recent U.S. Census). Prior studies suggest that the most accurate method would entail using the exact location of facilities, Census tracts, and a distance-based approach (Mohai and Saha 2006, 2007, 2015b). In particular, the purpose of this study is to determine whether disparate siting is responsible for present-day disparities surrounding CFPPs. This is the first national-level longitudinal environmental justice study using the distance-based approach to go back to 1950, the first study examining siting disparities for CFPPs, and the first national-level study to test Saha and Mohai's (2005) hypotheses about the importance of historical context in siting decisions. It will contribute to ongoing longitudinal environmental justice research by testing whether Mohai and Saha (2015b) findings for hazardous waste TSDFs are generalizable for other locally unwanted land-uses (LULUs).

CHAPTER 4: Methods

This study used distance-based methods to assess demographics in CFPPs host communities (or "host neighborhoods", areas within a 3.0-mile radius of CFPPs) at the time of plant siting and in 2010. Data were collected from a variety of sources including the U.S. Census and the EPA's Emissions Generation Dataset. ArcMap and SPSS were utilized for spatial and statistical analyses.

Identifying U.S. Coal-Fired Power Plant Facilities and Mapping Locations

U.S. Coal-fired power plants (CFPPs) were identified from two public databases in order to create an initial list of CFPPs for use in this study. The U.S. EPA's 2012 Emissions & Generation Dataset (eGRID 2012) provided CFPP names, locations, and capacities; while the U.S. Energy Information Administration (EIA)'s Electricity Generating Capacity database on Existing Units by Energy Source and Retired Units (2010 & 2011) provided the year each plant was sited and current operational status.

The databases contain information on all power plants in the U.S., from different fuel sources (such as nuclear, coal, and natural gas) and of varying capacities. Therefore, selection criteria were established so that the power plants' (1) primary fossil fuel category was coal[1] and (2) nameplate capacity (the total amount of power the facility can produce) was greater than or equal to 100 MW. A plant capacity of 100 MW is equivalent the electricity needed to power 75,000 – 100,000 homes at once (California ISO 2017). This criterion replicated the selection criteria of the NAACP "Coal Blooded" report (2011), the only other known study on CFPPs and community demographics. The selection yielded 409 plants, and ensured the power plants used in the study were exclusively commercial-sized CFPPs.

The databases also provided information on the CFPPs' location via latitude and longitude points, initial year of operation for current units, retirement status/year, and the type and year of scrubber installation, if any. However, other researchers have found inaccuracy within facility geographic coordinate data reported to the EPA; thus verification of CFPP location was needed (Mohai et al. 2009). Each plant's precise geographic coordinates were validated via a visual inspection of Google Maps and were confirmed through cross-checking addresses, accessing company information, and general internet searching. Often, in Google Maps, the CFPPs were

[1] Plant primary fuel types selected: bituminous, lignite, sub bituminous, waste coal, SGC, COG

identified by name, however visual inception also included looking for smoke stacks, coal conveyer belts, and coal ash piles. An example of a CFPP in Google Maps can be seen in Figure 4. In some cases, the EPA-provided geographic coordinates landed in an open field (See Figure 5), and therefore, this process was used to determine if the facility was nearby, decommissioned, or in another location. Seven plants were found to be contracted, but never built[2] and six additional plants were found to be duplicates of another facility (most often different names for plants or units in the same exact location);[3] thus, 13 CFPPs were eliminated from the study.

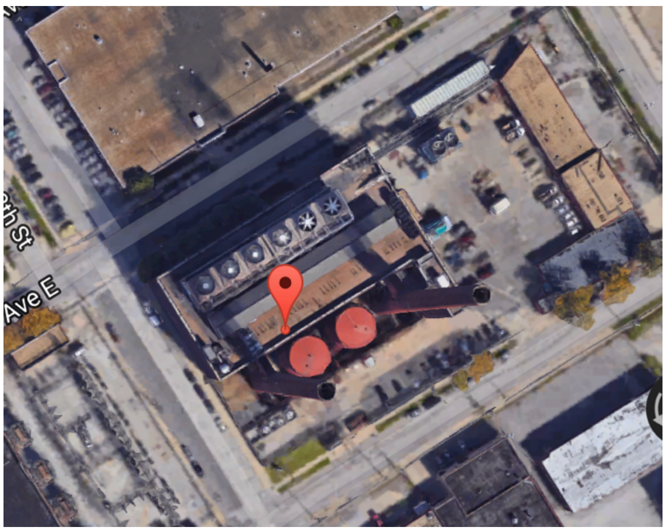

Figure 4. Google Maps images of an existing CFPP.
Figure 4 serves an example image of visual inspection results for a CFPP whose geographic coordinates were confirmed in Google Maps. The picture on the left is an areal view and the picture on the right is a street view of the same facility in Cleveland, Ohio.

[2] Ely Energy Center, Greene Energy Resource Recovery Project, Lovett, Medicine Bow Fuel & Power LLC, Plant Washington, Robinson Power Company LLC, Two Elk Generating Station
[3] Weadock, Sandow 5, Laramie River 2&3, Wygen III & Elm Road Generating Station, and Joliet 29

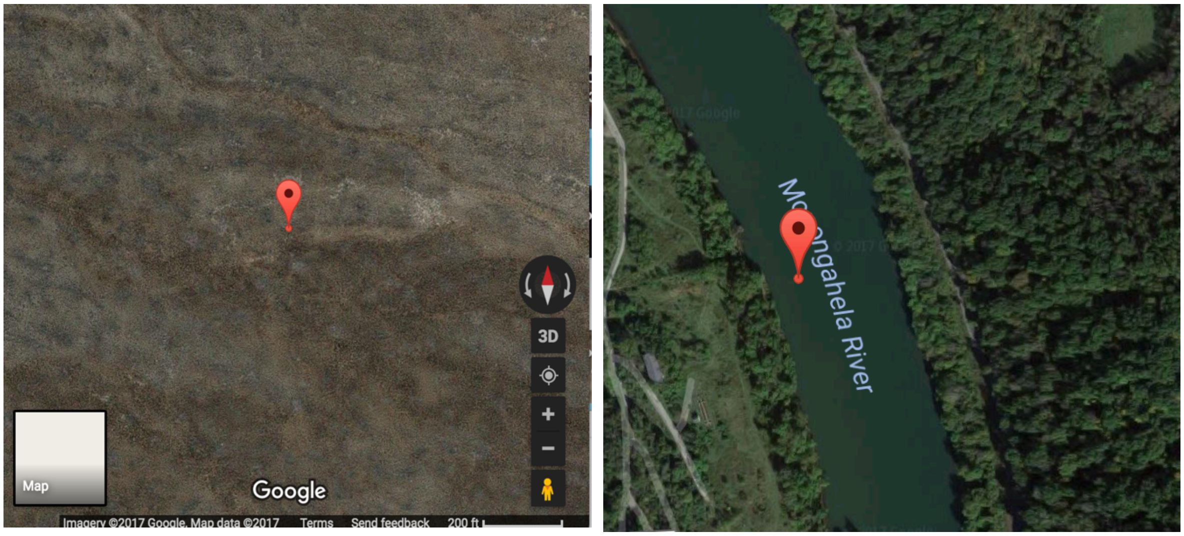

Figure 5. Google Maps images of CFPP geographic coordinates in open field.
Figure 5 provides example images of visual inspection results for CFPP geographic coordinates that landed in areas clearly not hosting an existing CFPP in Google Maps.

Facility Siting Dates

Although some of the aforementioned databases provided dates for when facilities were sited, some dates referred to the siting of currently operating units, rather than the facility itself. Many facilities had retired units that were constructed previously. Thus, the dates provided by the databases were inaccurate for the purpose of this study. Therefore, facility siting dates, i.e., the year each facility began operating, were also confirmed using a combination of assessing company information, general internet searching, and cross-checking plant names and addresses. Confirmation dates of facility siting, current retirement status and/or year were produced from a variety of sources, including plant/owner company websites, historical and recent newspaper reports, the SourceWatch database, and the Sierra Club's Beyond Coal Campaign.

The initial siting date for 384 out of the 396 facilities was verified or corrected. Twelve plants were cut from the study that were found to be fully decommissioned or converted to fuel stocks other than coal prior to January 1, 2012, as they were not within the scope of the study (existing plants as of 2012). Finally, Geographic Information System (GIS) software (ArcMap Version 10.4.1) was used to make an "x,y event layer" from the verified facility latitude and longitude points to map facility locations for further spatial analyses. The "Select by Attributes" tool was used to sort plants into categories by the nearest decennial Census according to the date of siting; for example, plants sorted into the "1950 Census" category included any plant sited between 1945-1954. However, elaborated on below, data collection was limited to urban areas and surrounding areas for many Census geographies prior to 1990. Therefore, any plant located in an area where Census information was not available for the associated siting decade was omitted from the the siting analysis for that decade. This process resulted in 17 total plants omitted, with 367 CFPPs for use in the study, of which locations are mapped in Figure 6.

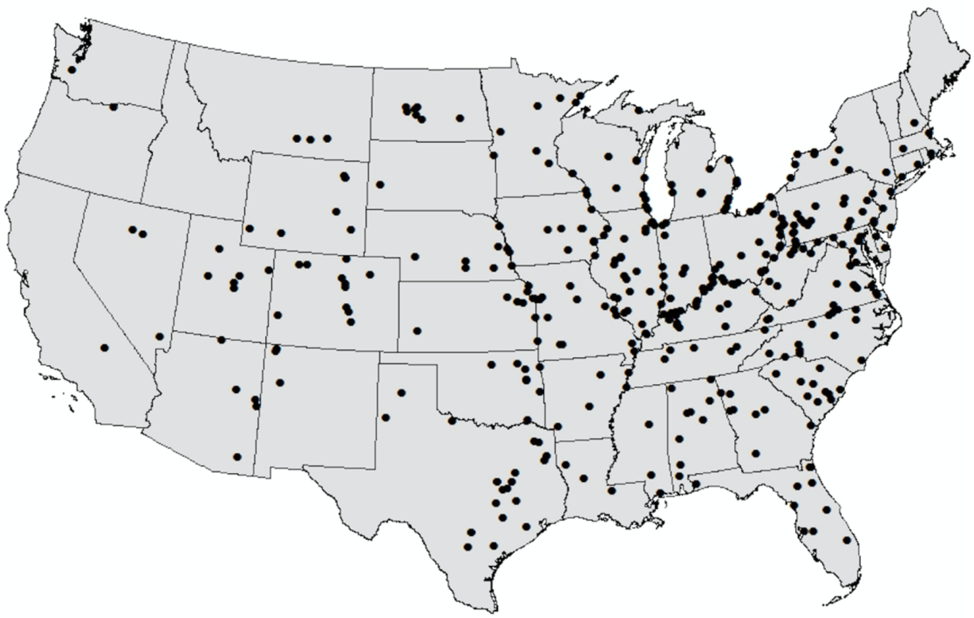

Figure 6. U.S. CFPP Study Sites.
Figure 6 depicts mapped locations of all CFPPs used in this study.

Demographic Data

To evaluate patterns of disparate siting, host community demographic characteristics for each of group of facilities were examined at or near the time of facility siting. Demographic characteristics are readily available from the U.S. Census through a continual American Community Survey. The decennial Census year closest to the siting dates of the groups of facilities were utilized between 1950 and 2010. Tabular demographic data from the 1950 to 2010 Censuses were obtained from the National Historic Geographic Information System database (NHGIS).[4]

[4] Minnesota Population Center. National Historical Geographic Information System: Version 11.0 [Database]. Minneapolis: University of Minnesota. 2016. http://doi.org/10.18128/D050.V11.0.

These decades were chosen because they matched the time periods for facility siting dates in the study. The tabular data included information based on "number of persons" in each variable category. Data from each of the Censuses were used to create four different categories of variables: Race/Ethnicity, Educational Attainment, Labor Force, and Income.

The race and ethnicity variables defined were percent White, percent nonwhite, percent Black and percent Hispanic or Latino. It should be noted that the Census Bureau definitions for many race and ethnicity variables changed significantly between 1950 and 2010. In 1950, race and ethnicity were only categorized as "White" or "Negro", or "other nonwhite", while in 2010, the race variable had five categories (White; Black; American Indian, Eskimo, or Aleut; Asian or Pacific Islander; or Other race) and another variable for Hispanic origin with nine categories, including indicators of Hispanic origin and race. However, the variables were reconstructed to be as comparable as possible across each decade for use in this study. For example, "nonwhite" population (i.e., "minority" population) was defined as the aggregate of nonwhite populations available for each Census year; however, where applicable, "non-Hispanic white" was subtracted from 'Total Population' to reflect the most accurate representation of minority populations (See Appendix I for a more detailed description of Census Variable Definitions). The Hispanic category was not reported by the Census Bureau until 1980. Hispanic variables were constructed and defined for prior years following the methods of previous studies (Mohai and Saha 2015b and Oakes, Anderton, and Anderson 1996) using Spanish surname and Spanish origin tabulations in 1960, 1970, and 1980.

Census data from the NHGIS were also used to create five socioeconomic variables. These five variables were chosen based on availability of the variables across all decades in the study and in line with variables that have been used in other recent empirical environmental justice studies (Mohai and Saha 2015b). The first variable, distribution of labor force, was broken into two categories: percent of persons 16 years old and over[5] employed in executive, managerial, or professional ("white collar") occupations; and percent employed in precision production or labor ("blue collar") occupations (as defined by Mohai and Saha 2015b). Additionally, percent of population 25 and over with high school degrees, percent of population 25 and over with 4-year college degrees, and mean family income were defined using education and family income

[5] Prior to 1970, this category was for persons 14 years old and over

variables. All variables were not available in every decade or certain geographic areas. In particular, 1960 Census county data for socioeconomic variables were unavailable. However, variables were made as similar as possible for each decade (Figure 7). See Appendix I for a more detailed description of Census Variable Definitions.

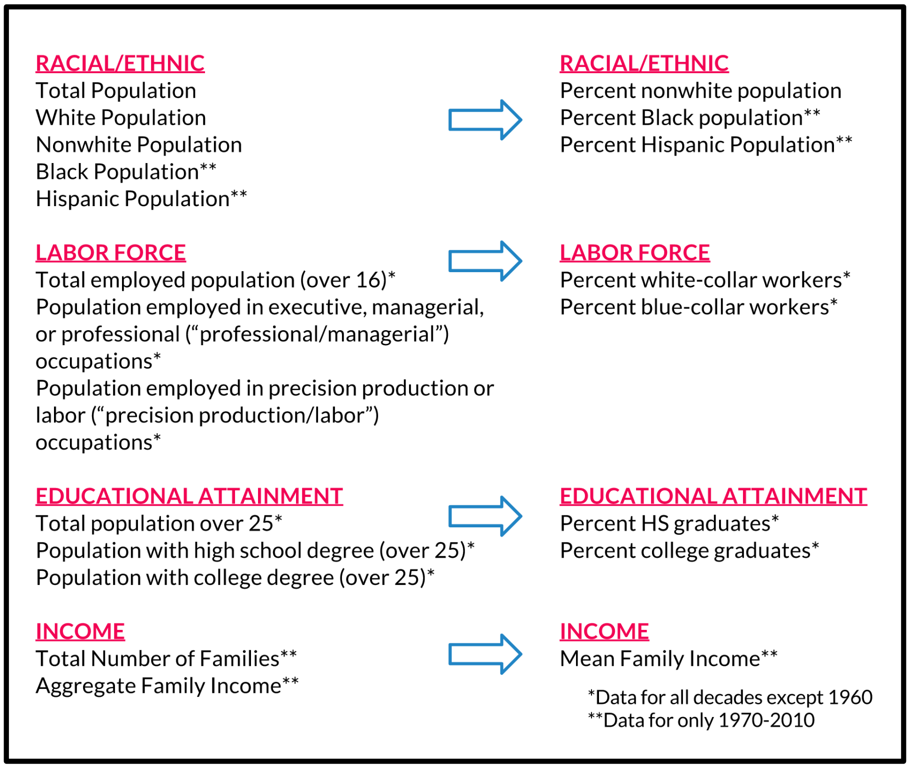

Figure 7. Census variables and categories.
Figure 7 depicts the variables downloaded from Census tabular data, and the new definitions created for purpose of this study. Each variable was not available at every decade: no asterisk indicates the variable was available in all decades, one asterisk indicates the variable was not available in 1960, and two asterisks indicate the variable was only available between 1970 and 2010.

Spatial Analysis

For this study, the power plant host community was defined as the collection of neighborhoods within a 3.0-mile radius of the CFPP. To define the host community boundaries, Census tract and county boundaries for each of the years (1950, 1960, 1970, 1980, 1990, 2000, 2010) were downloaded from the National Historic Geographic Information System database.[6] The downloaded Census boundaries were used with a GIS software (ArcMap Version 10.4.1) to

[6] More information on how the GIS boundary files were derived can be found on the NHGIS website, https://www.nhgis.org/documentation/gis-data

define “host communities”, areas within a 3.0-mile radius of the CFPP locations. This distance is consistent with the community size used in the only other national study related to CFPPs, the NAACP’s “Coal Blooded” Report.

Census tract units hosting or adjacent to the CFPP were used as the building block units for each community in applying this method for the 3.0-mile distance. Every unit that was at least partially intersected with the 3.0-mile radius was used. However, Census tracts were not drawn for locations in non-metropolitan areas for Censuses prior to 1990, meaning that Census data were not collected at the tract level in non-metropolitan areas (See Figure 8). Therefore, the next largest Census geography for which data were reported consistently was used to estimate the demographic characteristics in non-tracted areas. In these cases, the next largest Census geography for which data were reported consistently were counties. The use of both Census tracts and counties allowed the study to include longitudinal analyses of both non-metropolitan and metropolitan facilities, giving better representation of the nation’s CFPPs.

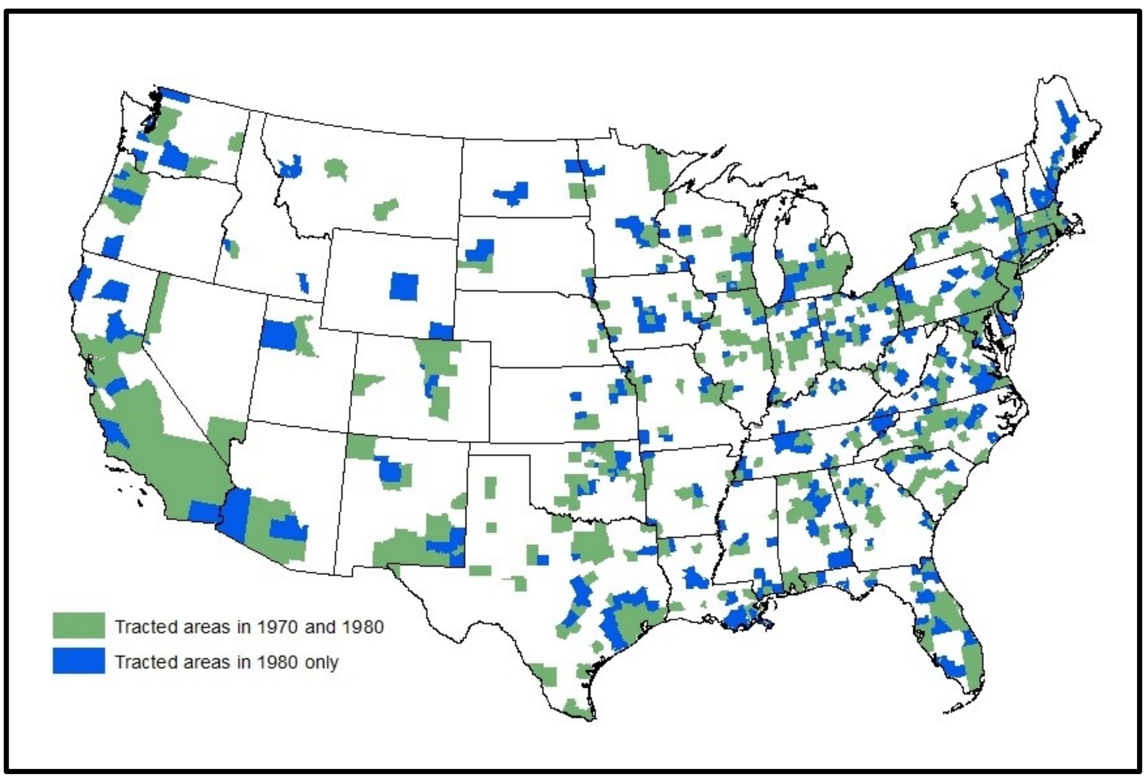

Figure 8. Census Tracted Areas in 1970 & 1980.
Figure 8 depicts the areas of the U.S. that had Census tracts drawn in 1970 and 1980. The areas in green were tracted in both 1970 and 1980, while the areas in blue were tracted only in 1980. Prior to 1970, fewer areas were tracted, whereas after 1980, Census tracts were drawn for the entire U.S.

For the longitudinal analyses, the distance-based method of areal apportionment (Mohai and Saha, 2006, 2007, and 2015b)[7] was used to determine the demographic characteristics of radial host communities within 3.0 and 50.0-miles of CFPP locations at the time of facility siting and within 3.0-miles of all CFPP locations in 2010. In carrying out the areal apportionment method, 3.0-mile and 50.0-mile "buffers" (i.e. circles with 3.0-mile and 50.0- mile radii) were created around each of the CFPPs and intersected with the Census tracts that fell at least partially within that boundary. The buffers were dissolved so that any populations that were encompassed by overlapping buffers were not double counted (See Figure 9).

Figure 9. Dissolving Overlapping Buffers.
Figure 9 depicts the process of dissolving two overlapping CFPP boundaries. This was done so that populations that fell within multiple CFPP boundaries were not double counted.

Next, the intersecting Census tracts' populations were weighted based on the proportion of the area of the Census tract that was captured by the 3.0 and 50.0-mile buffers surrounding the CFPP. For example, if 45% of the area of an adjacent Census tract is included in the 3.0-mile or 50.0 buffer, then 45% of the population in that tract is taken to estimate the population within the

[7] Census tract boundaries at a given location often changed from one Census year to the next between 1950 and 2010, however, Mohai and Saha (2007) found that the areal apportionment method produces consistent and reliable estimates of the demographic characteristics within a circular buffer around a given point location regardless of differences in the sizes and shapes of the building block units used to estimate the demographic characteristics within the buffer.

buffer. All of the populations in the Census tracts included in the 3.0-mile buffer were then aggregated and compared against the units included in the 50.0-mile buffer, and the units beyond 50.0-miles (the rest of the U.S.).

Traditionally, demographics within host communities are compared exclusively to the units that are not captured in the buffer within the U.S.; for example, within 3.0-miles and beyond 3.0-miles. This process was used to examine 2010 demographics around all CFPPs to replicate the NAACP report; however, in this study, community composition at the time of siting was also analyzed for disparities between racial and socioeconomic characteristics within 3.0 area and the area between 3.0 and 50.0-miles to account for regional differences. For example, Figure 10 depicts differences in the percent of the nonwhite population across the U.S. in 1980. In this map, it can be seen that the South had a high concentration of nonwhite populations compared to the northern U.S. A result, a host community in the South may have a higher percent nonwhite population than the U.S., indicating a disparity. Yet, that disparity may be attributed to regional distributions, not spatial disparities associated with the host community. By comparing the percent nonwhite population within 3.0-miles to that between 3.0 and 50.0-miles, regional differences are taken into account (Figure 11).

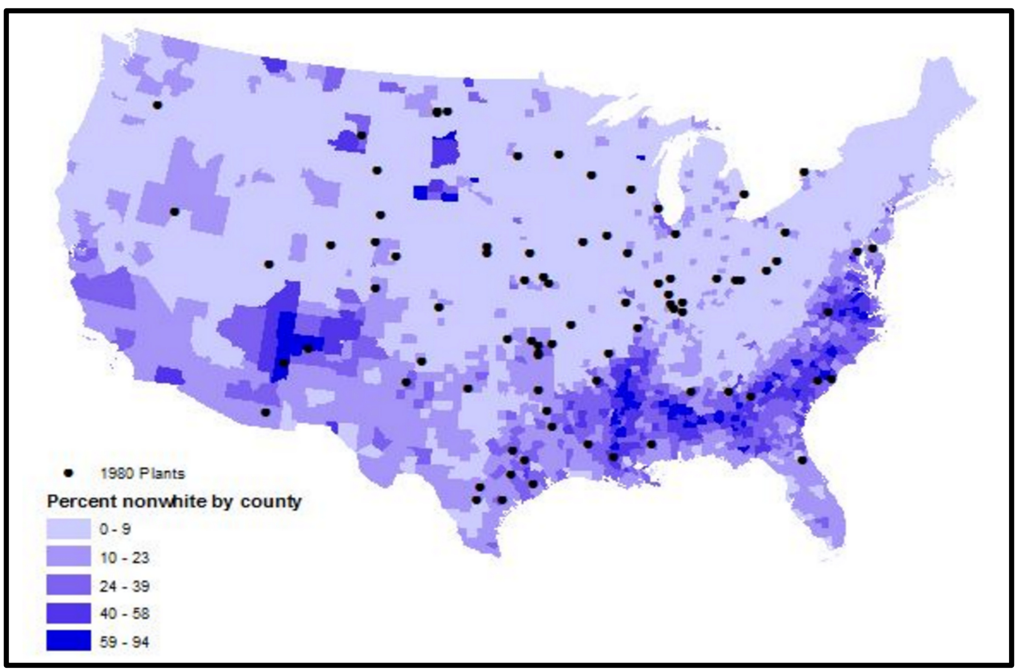

Figure 10. United States percent nonwhite population by county in 1980.
Figure 10 depicts the percent nonwhite population by county in 1980. From this map, regional differences in nonwhite population across the U.S. can be seen. Such differences may skew the disparities found around LULUs when using the traditional environmental justice comparison of "within host communities" and "beyond host communities."

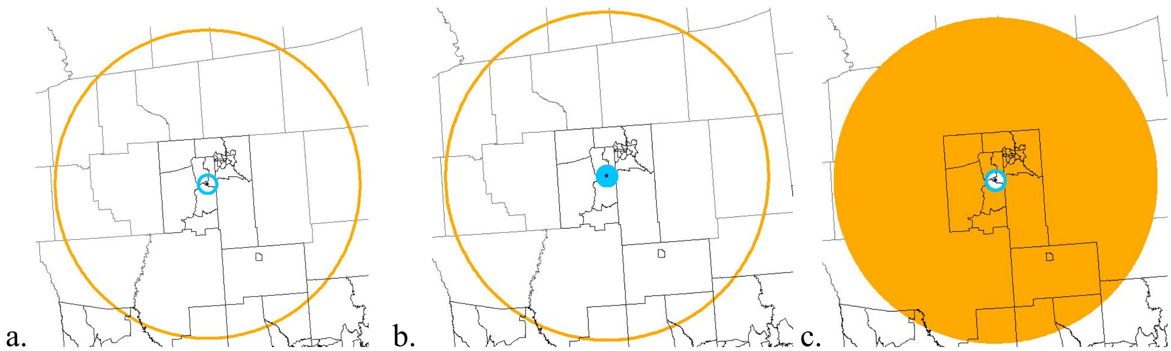

Figure 11. 3.0-mile and 50.0-mile buffer comparisons.
Figure 11a depicts the 3.0-mile buffer (blue) and 50.0-mile buffer (orange) around a coal-fired power plant; 11b depicts the initial unit of comparison (blue shading): within 3.0-miles of a facility; which is compared to 11c: the remaining 47.0 miles (orange area) between the 3.0 and 50.0-mile buffers.

Statistical Analyses

For descriptive analyses, the areal apportionment method was used to find the aggregate number of persons for each of the demographic categories compared to the aggregate total number of persons in each unit to create percentages at each of the applicable geographic distances. For the analysis evaluating present-day (2010) disparities for all existing CFPPs, the demographics within 3.0-miles of CFPPs were compared to demographics beyond 3.0-miles in the U.S., following the methods used by the NAACP report (2012). For the analyses at the time of siting, demographics were compared within 3.0-miles of a CFPP, between 3.0 and 50.0-miles of a CFPP, and beyond 50.0-miles of a CFPP in the U.S., which includes all areas not previously allocated. By comparing these three geographic units, I assessed whether racial composition and socioeconomic status of the communities around CFPPs were different from areas without CFPPs.

Multivariate statistical analyses (logistic regressions) were also used to determine whether the included racial and socioeconomic characteristics could be used to independently predict the areas in which CFPPs were sited in each of the Census years: 1950, 1960, 1970, 1980, 1990, 2000, and 2010. It is important, however, to note that very few plants existed within tracted areas in the 1950 and 1960 Census while approximately half of plants sited near 1970 and 1980 were within tracted areas. As a result, the logistic regressions for plants sited within the 1950 and 1960 decades could be skewed.

The multivariate analysis helped determine: 1) whether and which racial and socioeconomic characteristics of the communities best predict power plant locations at or near the timing of siting and in 2010, 2) whether racial characteristics are more important predictors than socioeconomic characteristics, and 3) whether the demographic patterns are consistent with prior longitudinal environmental justice studies using distance-based methods (for example Pastor, Sadd, and Hipp (2001), Saha and Mohai (2005), and Mohai and Saha (2015b)). In the regressions analyses, census tracts were the units of analysis and the 50% areal containment method was applied to determine which tracts lay inside the 3.0-mile radius of a CFPP and which lay beyond 3.0-miles in the U.S. Thus, the dependent variable was coded as a '1' if 50% or more of the tract lay within 3.0-miles of a CFPP location at the time of siting and a value of '0' if most of the tract lay beyond 3.0-miles in the U.S. The analysis was conducted for each of the CFPP siting periods discussed above and for all CFPPs in present-day (2010) conditions.

The Census variables used in the statistical analyses as independent variables included: mean family income; percent of persons 25 years old and over with a four-year college degree; percent employed in white collar occupations; percent minority; percent African American or black; percent Latino or Hispanic; percent Asian American or Pacific Islander; and mean property value, where the data was available (see Appendix I for definitions and description of the construction of these variables). These variables have been used in many prior quantitative environmental justice analyses. As mentioned previously, Census variables are often correlated with each other, potentially creating multi-collinearity problems in multivariate statistical analyses. Therefore, variance inflation factors (VIF) were examined in selecting variables to include in the regression equations such that the VIF were within the acceptable limit of less than 10 in all cases (See Appendix II) (Hair et al. 1995; Mohai and Saha 2015b). Although used in prior studies (Mohai and Saha 2015b), the variable 'percent employed in blue collar occupations' was removed from models due to multi-collinearity problems.

The main goals of the statistical analyses were to determine whether the patterns found in the descriptive analysis are statistically significant, to determine which variables best predict plant locations, and to determine whether the racial characteristics of areas are independent of the socioeconomic characteristics in predicting plant locations in answering the study's research questions:

1. Are there current (2010) racial and socioeconomic disparities between areas in the U.S. hosting CFPPs and those not hosting CFPPs?
2. Are current disparities surrounding CFPPs a result of disparate siting?
3. Are there differences in the patterns of disparate siting across decades prior to, during, and after the emergence of the modern environmental and environmental justice movements?

CHAPTER 5: Results

Overall, results showed present-day racial and socioeconomic disparities for all existing CFPPs based on the 2010 Census. In particular, percentages of nonwhite populations in current 3.0-mile CFPP host communities sited prior to 1945, between 1965 and 1974, and between 1985 and 1994 were greater than percentages of nonwhite population in the U.S. beyond 3.0-miles of CFPPs. Likewise, percentage of persons with 4-year college degrees, percentage of white collar occupations, and mean family income within current 3.0-mile CFPP host communities were lower than the educational attainment, occupation status, and mean family income beyond 3.0-miles of CFPPs in the United States. Descriptive analysis of community demographics within 3.0-miles of CFPPs at the time of siting yielded evidence for racial disparities between 1955 and 1984, but not prior or afterwards and showed evidence for socioeconomic disparities across all time periods in the study (1945 – 2012) outside of 1965 to 1974.

Multivariate analysis confirmed that race variables were independent, statistically significant predictors of CFPP locations for present-day (2010) host communities and for 3.0-mile host communities of CFPPs sited between 1965 and 1974, but not prior or afterward. These results are elaborated below.

Current (2010) Disparities

First, present-day (2010) demographics were evaluated using areal apportionment method to provide updated analysis similar to that of the NAACP 'Coal Blooded' Report (Wilson et al. 2011). The selection criterion for Wilson et al. (2011) and for this study were the same, however slight differences in methodologies include the use of the 2010 Census instead of the 2000 Census, the use of areal apportionment method instead of 50% areal containment method, and the different cut-off dates – 2008 for Wilson et al. (2011) and 2012 for this study. A total of 384 plants were evaluated using the 2010 Census. The analysis can be viewed as an update of Wilson et al. (2011) and was conducted to determine if current racial/ethnic and socioeconomic disparities exist around CFPPs.

Consistent with Wilson et al. (2011), population demographics were compared within 3.0-miles of CFPPs to beyond 3.0-miles of CFPPs. Present-day racial and socioeconomic disparities were found in aggregate for CFPPs sited before 2012 that met the selection criteria. Table 1 shows demographic data from the 2010 Census for plants sorted by each siting decade and in aggregate. The 2010 aggregate total population within host communities, i.e. areas within 3.0-miles of CFPPs, was 5,666,386 people using the areal apportionment method, which is consistent with the NAACP finding of 6 million people using 50% areal containment method in 2000 (See Table 2).

For racial/ethnic data, Table 1 and Figure 12 show that in 2010, host communities of CFPPs contained disproportionately high percentages of nonwhite populations compared to areas beyond 3.0-miles in the U.S., at 41 percent and 35 percent, respectively. Percent Black population was higher within 3.0-miles (17 percent) than beyond 3.0-miles (12 percent), as was percent Hispanic population within 3.0-miles (19 percent) compared to beyond 3.0-miles (16 percent).

In 2010, when all 384 facilities are taken into account, mean family income in 3.0-mile host neighborhoods ($69,068) was 15.2% less than the mean family income in areas beyond 3.0-miles ($81,476) (Table 2; Figure 12). Thus, mean family income was disproportionately low in CFPP communities. Similarly, the percentage of white-collar workers within host communities (57%) was less than the percentage of white-collar workers in the rest of the U.S. (61%) and the percentage of 4-year college graduates within 3.0-miles (31%) was less than the percentage of 4-year college graduates beyond 3.0-miles (36%).

These results indicate that racial/ethnic minorities, low-income, and less educated populations in the present-day are more greatly concentrated within 3.0-mile host neighborhoods than beyond 3.0-mile host neighborhoods. Racial disparities were found to be greater than the disparities found by Wilson et al. (2011) in the 2000 Census (See Table 2). In particular, in 2010, I found a 6 percent difference between percent nonwhite population within 3.0-miles of CFPPs (41%) and percent nonwhite population beyond 3.0-miles of CFPPs (35%) in 2010, while Wilson et al. (2011) found a 3 percent difference between percent nonwhite populations within 3.0-miles of CFPPs (39%) and percent nonwhite population beyond 3.0-miles of CFPPs (36%). This suggests that both the magnitude of racial disparities around CFPPs has increased between 2000 (3% difference) and 2010 (6% difference), and that the percentage of nonwhite populations living within 3.0-miles of CFPPs has increased by 2 percent between 2000 and 2010 (39% in 2000 compared to 41% in 2010) (See Table 2). Not only does this confirm that present-day racial disparities continue to exist within 3.0-miles of U.S. CFPPs as compared to areas beyond 3.0-miles, but it also appears that such disparities are increasing. Likewise, socioeconomic disparities consistent with Wilson et al. (2011) are found; however, direct comparisons are not possible given the use of different socioeconomic variables between the two studies.

Wilson et al. (2011) did not breakdown CFPPs by time of siting. However, because this study arranged CFPPs in cohorts by decade sited, I also examine current (2010) disparities around CFPPs by decade sited in order to see if there are specific cohorts of plants that are associated with greater present-day disparities than others. For example, although this study found that collectively, current CFPPs are disproportionately located in areas with higher concentrations of people of color, host communities containing CFFPs sited prior to 1945 (N= 36), between 1965 and 1974 (N= 78), and between 1985 and 1994 (N= 26), in particular, are currently (2010) composed of disproportionately high percentages of nonwhite populations when compared to areas beyond 3.0-miles of CFPPs nationwide. Percentages of present-day (2010) nonwhite populations in host communities with CFPPs sited prior to 1945 (52%), between 1965 and 1974 (52%), and between 1985 and 1994 (38%) were higher than percentages of nonwhites beyond 3.0-miles of CFPPs (35%), while present-day percent nonwhite populations within 3.0-miles of CFPPs sited in all other decades were less than the percentages of nonwhites beyond 3.0-miles of CFPPs. The plants sited in the racially disparate time periods equal 140 out of 384 existing CFPPs (36%); and 2,946,490 people out of 5,666,386 total people living within 3.0-miles of CFPPs in 2010 (52%). Furthermore, host communities containing CFPPs that were sited in these time periods also have disproportionately low mean income families, as is the case for host communities containing CFPPs sited in all time periods (Table 1).

Variable	*within 3.0-miles*									*beyond 3.0-miles*
CFPPs by Date Sited*	**pre-1945**	**1945-54**	**1955-64**	**1965-74**	**1975-84**	**1985-94**	**1995-2004**	**2005-12**	**Total**	**Total**
Number of Facilities	36	67	74	78	83	26	10	10	384	NA
Total Population (2010)	1,515,308	1,350,774	988,089	1,111,816	293,940	319,366	54,706	32,387	5,666,386	295,030,435
Percent Nonwhite (2010)	52	33	30	52	26	38	14	15	41	35
Percent Black (2010)	18	15	13	19	14	24	6	9	17	12
Percent Hispanic (2010)	28	13	14	24	6	7	5	3	19	16
Percent 25+ population with high school degree (2010)	29	31	33	31	33	34	41	38	31	29
Percent of 25+ population with 4-year college degree (2010)	31	33	28	32	30	29	26	26	31	36
Percent 16+ population with white-collar job (2010)	55	59	56	56	58	58	58	51	57	61
Percent 16+ population with blue-collar job (2010)	45	41	44	44	42	42	42	49	43	39
Mean family income (2010)	65,055	72,890	70,427	67,376	73,158	68,255	69,975	59,581	69,068	81,476

*CFPPs are arranged by decade sited using the midpoint method. As such, CFPPs labeled "1950" were sited between 1945 and 1954, so on and so forth.

Table 1. Present-Day (2010) Racial and Socioeconomic Disparities for All Existing CFPPs as of 2012.

Table 1 depicts the present-day (2010) demographic characteristics within CFPP host communities in aggregate and by siting decade. Overall, racial and ethnic minorities and low-income populations are more greatly concentrated within 3.0-miles of CFPPs than beyond 3.0-miles of CFPPs in the U.S.

Variable	*within 3.0-miles*		*beyond 3.0-miles*	
Distance	**2000 (Wilson et al. 2011)**	**2010 (present study)**	**2000 (Wilson et al. 2011)**	**2010 (present study)**
Percent nonwhite population	39%	41%	36%	35%
Income	$18,400 (per capita)	$69,068 (per family)	$21,587 (per capita)	$81,476 (per family)

*The Wilson et al. used per capita income as a metric, while I used mean family income as a metric, thus the two decades should not be directly compared.

Table 2. Comparison between demographics around CFPP 3.0-mile host communities in 2000 and 2010.

Table 2 depicts the demographics characteristics within 3.0-mile host communities and beyond 3.0-mile host communities found by Wilson et al. (2011) using the 2000 Census and the demographic characteristics found by this study using the 2010 Census. Racial and socioeconomic disparities can be found in both 2000 and 2010.

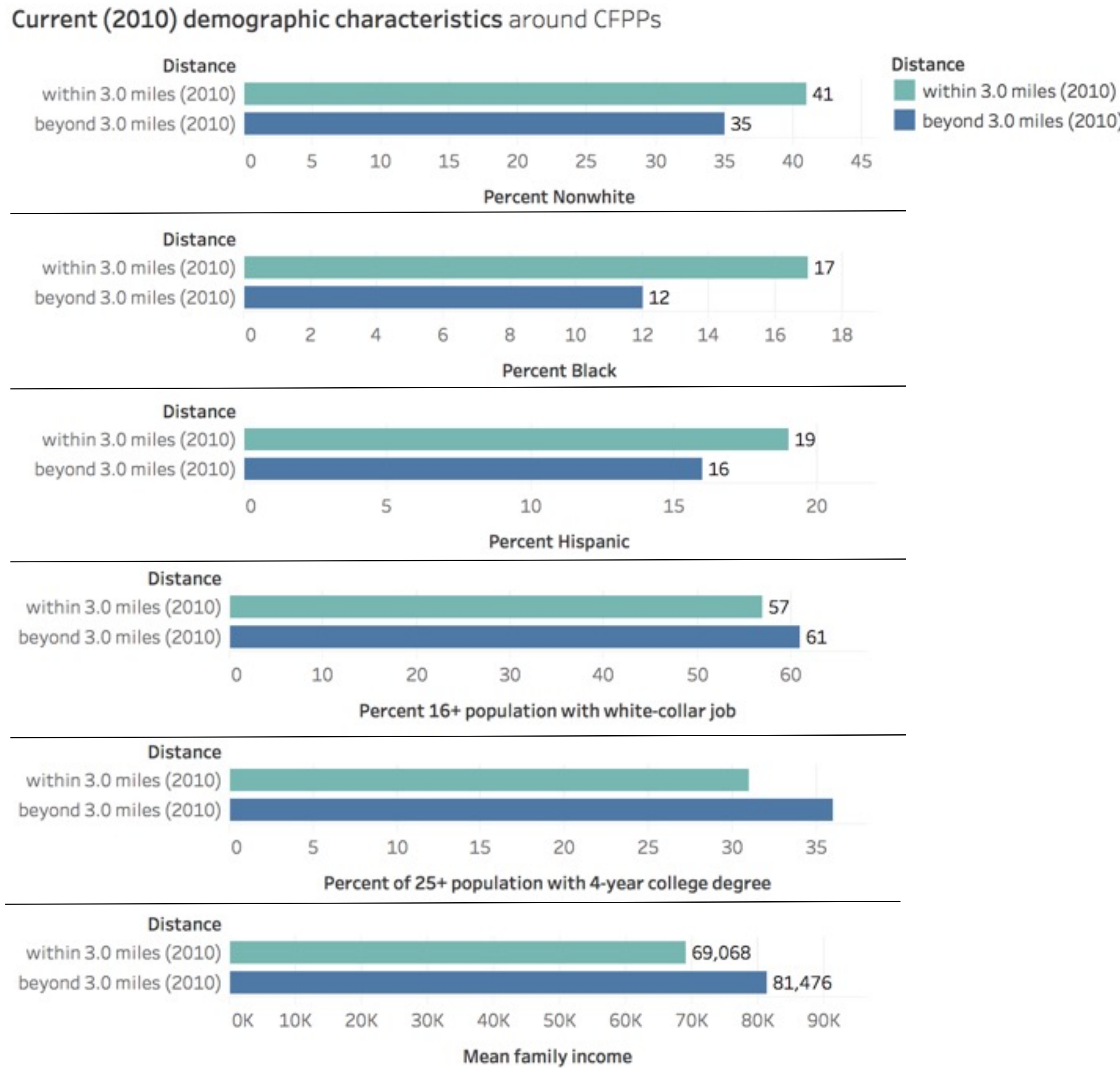

Figure 12. Present-day (2010) demographic characteristics around all existing CFPPs.

Figure 12 graphically depicts the present-day (2010) demographic characteristics within 3.0-mile CFPP host communities compared to the demographic characteristics beyond 3.0-mile host communities.

Disparities at Time of Siting

Thirty-one facilities were sited prior to 1945, sixty-one facilities were sited in the between 1945 and 1954, sixty-nine between 1955 and 1964, seventy-seven between 1965 and 1974, eighty-three between 1975 and 1984, twenty-six between 1985 and 1994, ten between 1995 and 2004, and ten between 2005 and 2012 (See Table 3). To determine whether current disparities existed at the time of siting, four variables were evaluated: percent nonwhite population, percent blue-collar workers, percent college graduates, and mean family income.

Period of Siting	***# of CFPPs***	***% of Total***	***Cumulative # of CFPPs***	***Cumulative % of Total***
Pre-1945	31	8%	31	8%
1945 - 1954	61	17%	92	25%
1955 - 1964	69	19%	161	44%
1965 - 1974	77	21%	238	65%
1975 - 1984	83	23%	321	89%
1985 - 1994	26	7.0%	347	95%
1995 - 2004	10	3.0%	357	97%
2005 - 2012	10	3.0%	367	100%
Total	367	100%	367	100%

Table 3. Coal-Fired Power Plants by Period of Siting.
Table 3 depicts the number and percent of facilitates sited before 1945 and within each ten-year interval thereafter within the time period of the study (until 2012).

Race/Ethnicity Variables

The existence of racial/ethnic disparities for CFPPs at the time of siting varied by decade. As indicated in Figure 13 and Table 4, the percent nonwhite population within 3.0-miles of CFPPs sited around 1950 (5%) was less than the percent nonwhite population between 3.0 to 50.0-miles of CFPPs sited around 1950 (9%). Starting in the 1955 to 1964 time period and during the next two time periods examined (1965-1974 and 1975-1984) percentages of nonwhites within 3.0-miles of CFPPs sited in the respective time periods (13, 16, and 15 percent) were greater than the respective percentages in areas between 3.0 and 50.0-miles (11, 7, and 13 percent) (Table 4 and 5). Percentages of nonwhite populations beyond 50.0-miles of CFPPs were in the expected direction. For example, from 1945 to 1954, percent nonwhite populations within 3.0-miles of CFPPs (5%) was less than percentage nonwhite populations beyond 50.0-miles of CFPPs (11%), which is similar to the finding that the nonwhite percentage within 3.0-miles was less than the nonwhite percentage between the 3.0 and 50.0 mile areas (9.0%). In sum, results indicate that for CFPPs sited from 1955 to 1984, but not prior or afterward, nonwhite populations were more greatly concentrated in CFPP host neighborhoods than non-host communities in the U.S. at the time of siting. This is particularly important, as the large majority (73%) of CFPPs (Table 3) were sited precisely during the same decades (1960's, 1970's, 1980's) disparate siting in communities of color was occurring more broadly (Saha and Mohai 2005). Further, the greatest contrast between nonwhite populations within 3.0-miles of CFPPs and nonwhite populations beyond 3.0-miles of CFPPs occurred in the 1965 to 1974 time period, which involved the siting of 77 (21%) new plants. This is precisely the period that Saha and Mohai (2005) identified as the start of environmental consciousness in the U.S. that spurred the NIMBY syndrome.

Beginning in the 1985 to 1994 period and during the next two time periods (1995-2004 and 2005-2012) (Table 6), results indicate that such racial/ethnic siting disparities are no longer present, as the percent nonwhite populations within 3.0-mile host communities (22, 8, and 15 percent, respectively) were less than the respective areas between 3.0 and 50.0-mile of CFPPs (23, 36, and 25 percent) at the time of siting. Nonwhite populations for areas beyond 50.0-miles of CFPPs remained greater than the nonwhite populations within 3.0-miles of CFPPs at each respective time period. The finding of racial disparities for CFPPs sited in 1955 through 1984 supports the hypothesis that siting disparities would be found for CFPPs sited during the height of the environmental movement and the NIMBY phenomenon, and are similar to the results found by Saha and Mohai (2005) for hazardous waste TSDFs. It is also important to note that CFPPs sited after 1985 had to meet the stringent requirements of the Clean Air Act, and could no longer avoid emissions controls like grandfathered plants (contracted prior to 1967), were able to. Therefore, although whiter communities were more likely to get sited for new plants after 1985, these plants were likely cleaner than the earlier plants sited where people of color tended to live. Possible explanations for why such racial disparities do not exist for host communities sited in 1985 through 2012 will be elaborated on in Chapter 6, although plants sited between 1985 and 2012 only make up 13% of CFPPs sited during the time periods in this study.

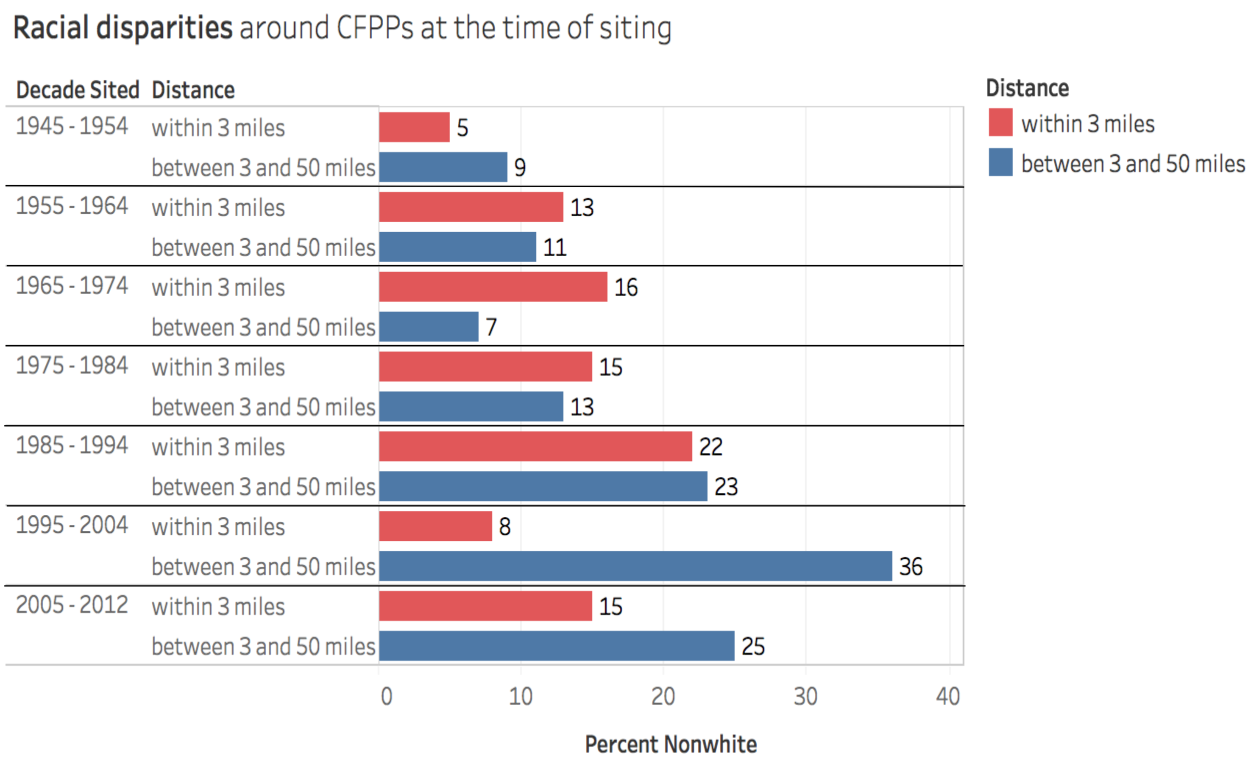

Figure 13. Racial disparities around CFPPs at the time of siting.
Figure 13 compares the percentage of nonwhite people in populations around CFPPs at the time of siting.

CFPPs by Decade Sited	1945 - 1954*			1954 - 1964		
Variable	*within 3 miles*	*between 3 and 50 miles*	*beyond 50 miles*	*within 3 miles*	*between 3 and 50 miles*	*beyond 50 miles*
Total Population	745,304	49,417,034	86,973,529	822,102	66,874,199	105,839,638
Percent Nonwhite	5.0	9.0	11	13	11	11
Percent Black**	NA	NA	NA	10	13**	NA
Percent Hispanic	NA	NA	NA	NA	NA	NA

*CFPPs are arranged by decade sited using the midpoint method. As such, CFPPs labeled "1950" were sited between 1945 and 1954, so on and so forth.
**Percent Black population data were available for the 1960 Census in tracted areas only. These results reflect only urban areas sited for CFPPs beyond 3.0-miles.

Table 4. Racial Disparities around CFPPs at the time of siting for 1945 – 1964.
Table 4 depicts the aggregate racial demographics within 3.0-miles of CFPPs, between 3.0 and 50.0-miles of CFPPs, and beyond 50.0-miles at the time of siting for 1945 – 1964.

CFPPs by Decade Sited	1965 - 1974			1975 - 1984		
Variable	*within 3 miles*	*between 3 and 50 miles*	*beyond 50 miles*	*within 3 miles*	*between 3 and 50 miles*	*beyond 50 miles*
Total Population	1,108,054	65,608,270	73,156,327	200,582	28,718,544	90567214
Percent Nonwhite	16	7.0	15	15	13	12
Percent Black	15	7.0	13	12	10	9.0
Percent Hispanic	12	1.0	6.0	2.0	3.0	4.0

Table 5. Racial Disparities around CFPPs at the time of siting for 1965 – 1984.
Table 5 depicts the aggregate racial demographics within 3.0-miles of CFPPs, between 3.0 and 50.0-miles of CFPPs, and beyond 50.0-miles of CFPPs at the time of siting for 1965 - 1984.

CFPPs by Decade Sited	**1985 - 1994**			**1995 - 2004**			**2005 - 2012**		
Variable	***within 3 miles***	***between 3 and 50 miles***	***beyond 50 miles***	***within 3 miles***	***between 3 and 50 miles***	***beyond 50 miles***	***within 3 miles***	***between 3 and 50 miles***	***beyond 50 miles***
Total Population	305,755	26,551,619	221,750,966	51,622	17,795,627	250,580,022	32,387	7,530,023	293,134,411
Percent Nonwhite	22	23	25	8.0	36	30	15	25	36
Percent Black	17	14	12	5.0	26	11	9.0	18	12
Percent Hispanic	2.0	5.0	9.0	2.0	6.0	13	3.0	4.0	16

Table 6. Racial Disparities around CFPPs at the time of siting for 1985 - 2012.
Table 6 depicts the aggregate racial demographics within 3.0-miles of CFPPs, between 3.0 and 50.0-miles of CFPPs, and beyond 50.0-miles of CFPPs at the time of siting for 1985 – 2012.

Socioeconomic Variables

<u>Educational Attainment</u>

Educational disparities around CFPPs existed for all time periods except for 1945 to 1954 (Tables 7 and 8, Figure 14). For CFPPs sited between 1945 and 1954, the percentage of people 25 and over with a 4-year college degree within 3.0-miles (7%) was greater than the percentage of people 25 and over with a 4-year college degree between 3.0 and 50.0-miles (5%). In contrast, for host communities sited during the six other time periods from 1955 to 2012, a disproportionately smaller percentage of the population earned 4-year college degrees (4, 6, 11, 22, 20, and 51 percent, respectively) when compared to populations between 3.0 and 50.0-miles of CFPPs (9, 10, 13, 26, 30, and 58 percent, respectively). Percentages of people with college degrees for areas beyond 50.0-miles of CFPPs were generally even higher than areas between 3.0 and 50.0 miles. Furthermore, it appears that these disparities show an increasing trend over time.

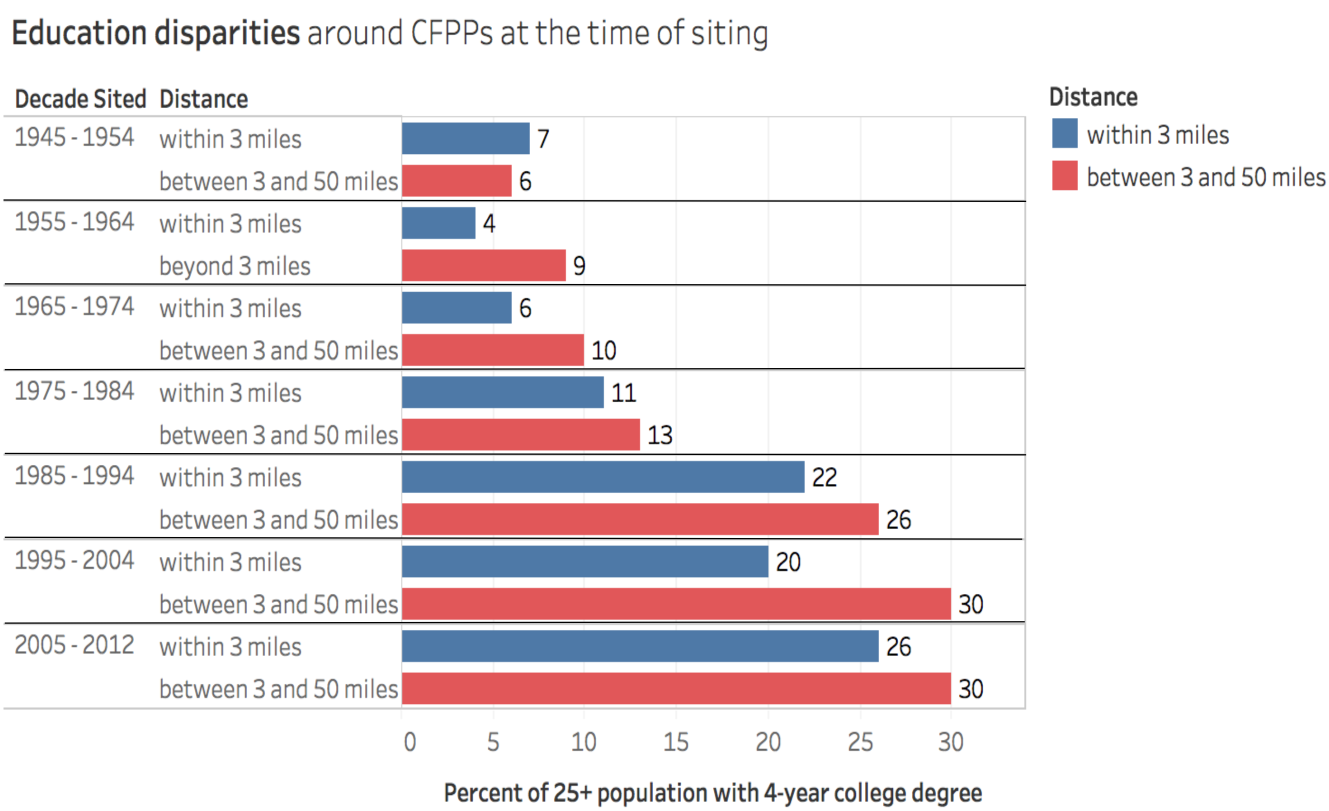

Figure 14. Education disparities around CFPPs at the time of siting.
Figure 14 compares the percentage of people 25 and over with a 4-year college degree in populations around CFPPs at the time of siting.

CFPPs by Decade Sited	1945 - 1954*			1955 - 1964**		1965 - 1974			1975 - 1984		
Variable	***within 3 miles***	***between 3 and 50 miles***	***beyond 50 miles***	***within 3 miles***	***beyond 3 miles***	***within 3 miles***	***between 3 and 50 miles***	***beyond 50 miles***	***within 3 miles***	***between 3 and 50 miles***	***beyond 50 miles***
Percent 25+ population with high school degree	24	21	20	21	26	28	31	31	39	36	35
Percent 25+ population with 4-year college degree	7	6	6	4	9	6	10	10	11	13	14
Percent 16+ population with white-collar job	42	38	37	26	38	42	32	54	47	47	47
Percent 16+ population with blue-collar job	56	61	61	68	57	58	39	65	53	53	53
Mean family income	NA	NA	NA	NA	NA	$23,611.69	$10,055.09	$10,138.83	$22,214.37	$21,242.01	$20,893.98

*CFPPs are arranged by decade sited using the midpoint method. As such, CFPPs labeled "1950" were sited between 1945 and 1954, so on and so forth.
**Socioeconomic data for 1960 were limited at the county level, therefore aggregates for plants sited from 1955 - 1964 reflect only urban areas where tract-level data were available. Because of this limitation, data were not available between 3 and 50.0-miles.

Table 7. Socioeconomic Disparities around CFPPs at the time of siting for 1945 – 1984.
Table 7 socioeconomic demographics within 3.0-miles of CFPPs, between 3.0 and 50.0-miles of CFPPs, and beyond 50.0-miles of CFPPs at the time of siting for 1945-1984.

CFPPs by Decade Sited	1985 - 1994			1995 - 2004			2005 - 2012		
Variable	***within 3 miles***	***between 3 and 50 miles***	***beyond 50 miles***	***within 3 miles***	***between 3 and 50 miles***	***beyond 50 miles***	***within 3 miles***	***between 3 and 50 miles***	***beyond 50 miles***
Percent of 25+ population with high school degree	33	32	30	42	30	29	38	34	29
Percent of 25+ population with 4-year college degree	22	26	27	20	30	31	26	30	36
Percent 16+ population with white-collar job	56	59	58	55	61	60	51	58	61
Percent 16+ population with blue-collar job	44	41	42	44	39	40	49	42	39
Mean family income	$38,512.30	$43,844.20	$43,805.37	$52,184.80	$65,131.29	$64,887.59	$59,580.78	$69,214.65	$81,577.00

Table 8. Socioeconomic Disparities around CFPPs at the time of siting for 1985 – 2012.
Table 8 depicts the aggregate socioeconomic demographics within 3.0-miles of CFPPs, between 3.0 and 50.0-miles of CFPPs, and beyond 50.0-miles of CFPPs at the time of siting for 1985 – 2012.

Occupation

The breakdown between percentage of white-collar and blue-collar workers within CFPP host communities also varied across decade (Table 7 and 8, Figure 15). In this category, lower proportions of white-collar workers indicate a socioeconomic disparity, with relatively less people holding managerial/professional positions and likely, higher paying jobs. From 1945 - 1954, the percentage of white-collar workers within 3.0-miles of newly sited CFPPs (42%) was greater than the percentage of white-collar workers in areas between 3.0 and 50.0-miles (38%), showing no disparity, as expected. From 1955 to 1964, the percentage of white-collar workers within 3.0-miles of CFPPs (26%) was less than the percentage of white-collar workers in areas between 3.0 and 50-miles (38%), indicating a stark disparity. Yet, between 1965 and 1974, the percentage of white-collar workers in 3.0-mile host communities sited for CFPPs (42%) was again greater than the percentage of white-collar workers in areas between 3.0 and 50.0-miles (32%). However, percentages of white-collar workers beyond 50.0-miles of CFPPs (54%) was greater than the percentages of white-collar workers both within 3.0-miles and between 3.0 and 50.0-miles of sited CFPPs. These results indicate that managerial/leadership positions were in greater proportions well beyond communities sited for CFPPs.

For the four time periods beginning from 1975 to 1984, percentages of white-collar workers in 3.0-mile host communities at or near the time of siting (47, 56, 55, and 51 percent) was equal to or less than the respective percentage of white-collar workers between 3.0 and 50.0-miles of CFPPs (47, 59, 61, and 58 percent). Occupation characteristics for areas beyond 50.0-miles of CFPPs followed similar patterns when compared to areas within 3.0-miles of CFPPs. These results indicate little to no socioeconomic disparity in resident occupations of host communities sited between 1945 and 1954 and between 1965 and 1974, but sustained disparities in communities sited for CFPPs between 1975 and 2012. Communities in the latter time periods also seem to be the areas where educational attainment is also less, while the proportion of whites is relatively high, which lends support for sociopolitical explanations. This finding may also be explained by increased rural locations of new plants.

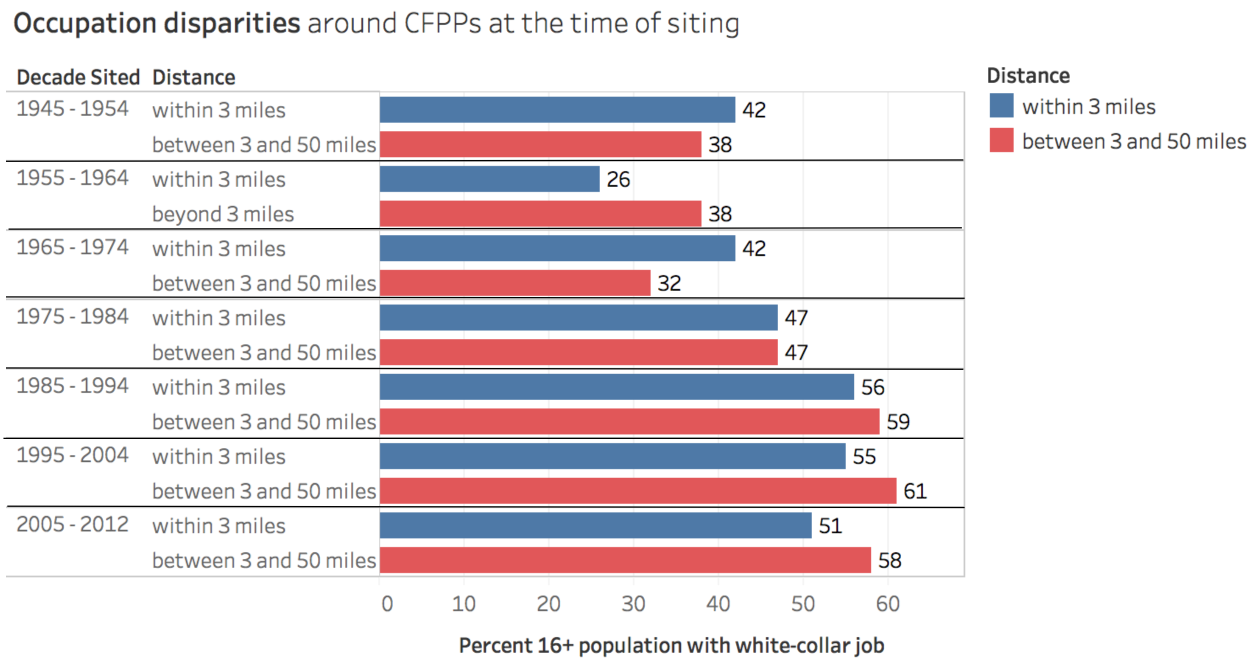

Figure 15. Occupation disparities around CFPPs at the time of siting.
Figure 15 compares the percentage of white-collar workers in populations around CFPPs at the time of siting.

<u>Mean Family Income</u>

Mean family income data was only available in the 1970 Census onward, yet also showed a variance of disparities across different siting decades (Table 7 and 8, Figure 16). For CFPPs sited between 1965 and 1974, the mean family income within 3.0-mile host communities ($18,240) was 79% greater than the mean family income between 3.0 and 50.0-miles of CFPPs ($10,206). Similarly, for CFPPs sited between 1975 and 1984, mean family income was 5% greater within 3.0-miles host communities ($22,214) when compared to mean family income between 3.0 and 50.0-miles of CFPPs ($21,242). However, results indicate that for CFPPs sited from 1985 onward, socioeconomic disparities were reflected in mean family income of host neighborhoods, as the mean family income within 3.0-mile host communities at each siting decade was less for than the mean family income between 3.0 and 50.0-miles of CFPPs. From 1985 to 1994, mean family income was 12% less within 3.0-miles of CFPPs than mean family income between 3.0 and 50.0-miles; from 1995 to 2004 it was 20% less within 3.0-miles than between 3.0 and 50.0-miles; and from 2005 to 2010 it was 16% less. Mean family income for areas beyond 50.0-miles of CFPPs followed similar patterns when compared to areas within 3.0-miles of CFPPs. For CFPPs sited from 1965 to 1974, mean family income was greater within 3.0-miles of CFPPs than beyond 50.0-

miles of CFPPs, but for all subsequent time periods mean family income within 3.0-miles of CFPPs was less than mean family income in areas beyond 50.0-miles of CFPPs at the time of siting for in each respective time period.

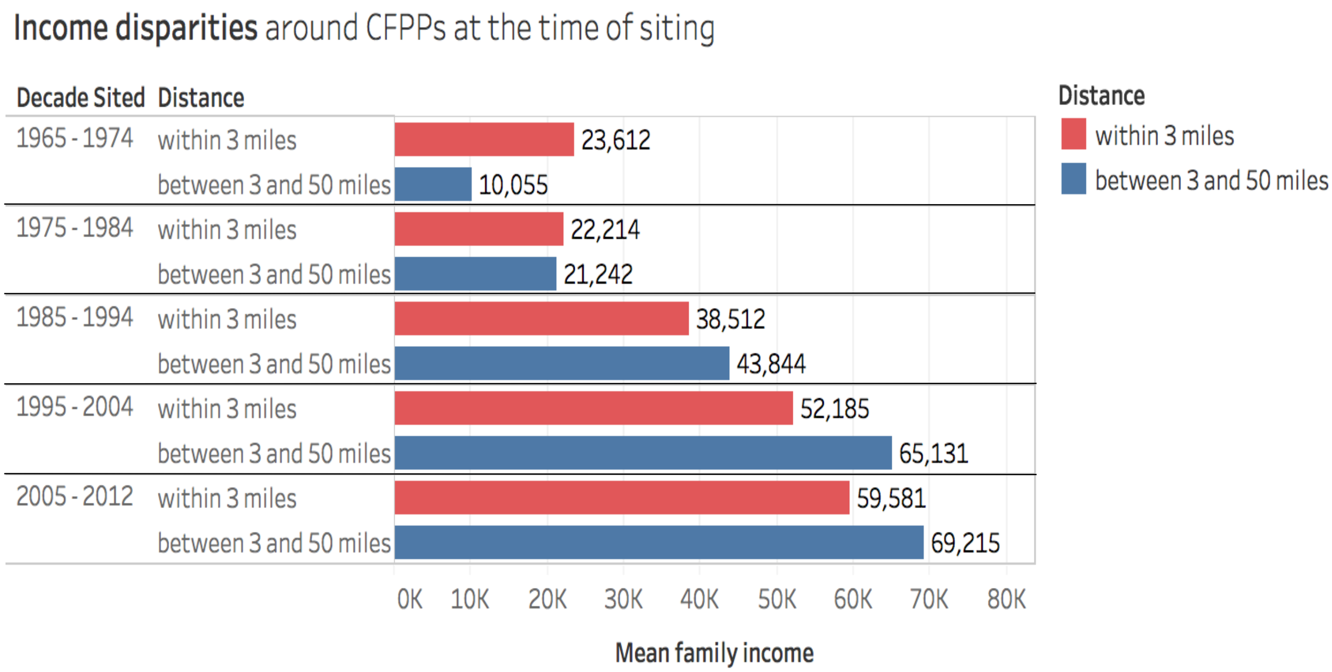

Figure 16. Income disparities around CFPPs at the time of siting.
Figure 16 compares mean family income of populations around CFPPs within 3.0 and 50.0-miles at each siting decade.

The finding of lower percentages of persons with college degrees in areas within 3.0-miles of CFPPs sited between 1965 and 2012, and lower percentages of white-collar workers and lower mean family income from 1985 onward, indicate lower socioeconomic levels for host neighborhoods at the time of siting, relative to surrounding areas within 50.0-miles. This yields mixed support for the hypothesis that socioeconomic siting disparities would increase after the start of the environmental movement in the mid-1960's, and is similar to evidence found for hazardous waste TSDFs (Saha and Mohai 2005). However, we would also expect a decrease in socioeconomic disparities in recent decades because of the environmental justice movement, which was not found. Possible explanations for these results, and in particular, the existence of socioeconomic siting disparities, but not racial siting disparities in 1990 onward, are discussed in Chapter 6.

Logistic Regression Results

Given the considerable debate in the environmental justice literature about the relative importance of race and class in predicting hazardous facility locations (Mohai et al. 2009), logistic regressions were used to test whether present-day racial disparities and the racial disparities found at the time of siting of CFPPs were independent or largely the result of higher concentrations of people of color living in poor socioeconomic conditions. For each time period, four models were created to determine (a) if race/ethnicity variables combined (i.e., “minority”) was a statistically significant predictors of CFPP locations at the time of siting (Models 1) (b) whether it remained so after controlling for mean property values and other socioeconomic variables (Models 2), (c) whether separate race/ethnicity variables (i.e., Black, Hispanic, and Asian and Pacific Islander) were statistically significant predictors of facility locations at the time of siting (Models 3), and (d) whether they remained so after controlling for mean property values and other socioeconomic variables (Models 4). The distinction between Models 1 and 2 and Models 3 and 4 allows us to determine whether racial disparities around CFPPs are a function of socioeconomic disparities, whether both race and socioeconomic variables are independent predictors of CFPP locations, and if so which variables are the most important. These results are shown in Tables 9 – 16.

When examining the results of a cross-sectional analysis of present-day racial and socioeconomic conditions around all CFPPs (Table 9), percent minority population (Model 1), percent Black, and percent Hispanic (Model 3) were found to be statistically significant predictors of CFPP locations. When mean property values, percent with a 4-year college degree, percent in white collar occupations, and mean family income were included in the equation (Models 2 and 4), the racial/ethnic variables remained statistically significant predictors of facility locations in the expected directions (i.e. tracts with higher percentages of minority populations were more likely to be near a CFPP). In this model, mean property values, percent in white collar occupations, and mean family income predicted in the expected direction (i.e. tracts with relatively low mean property values, percentages in white collar occupations, and mean family income were more likely to be near a CFPP); however, percent in white collar occupations was not significant. Percent with a 4-year college degree was a significant predictor in the unexpected direction (i.e. the expected direction is that tracts with a higher percentage of persons with a 4-year college degree are less likely to be near a CFPP).

In comparing these results with the descriptive analysis (Figure 10, Table 2), the regression results were not surprising given that both racial and socioeconomic disparities were present. At the very least, these results present evidence for both racial discriminatory and sociopolitical explanations for current conditions around CFPP locations, because race variables, combined as "minority" and by racial/ethnic group alone were all independent, significant predictors of CFPP location. In particular, higher percentages of minority peoples, independent from socioeconomic factors, lend support for hypotheses that intentional or side-effect discrimination (racial discriminatory explanations) influence community composition around CFPPs, as well as support for the hypothesis that facilities are more likely to be in communities that do not have the social capital and resources to generate opposition (sociopolitical explanations). Next, regression analyses were applied to determine whether the racial and socioeconomic variables remained statistically significant independent predictors of facility siting for each of the time periods and whether the patterns varied over time.

Variables	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)	Model 4, OR (95% CI)
All Existing CFPPs *2010 Census*				
% Minority	1.011*** (1.009, 1.012)	1.009*** (1.007, 1.011)		
% Black			1.013*** (1.011, 1.014)	1.009*** (1.006, 1.011)
% Hispanic			1.011*** (1.008, 1.013)	1.011*** (1.008, 1.013)
% Asian American / Pacific Islander			.994 (.987, 1.001)	1.011** (1.003, 1.019)
% with college degree		1.021*** (1.014, 1.028)		1.021*** (1.014, 1.028)
% in white collar occupations		.978*** (.971, .984)		.979*** (.972, .986)
mean housing value (owner-occupied)		.998*** (.997, .998)		.998*** (.997, .998)
mean family income ($1,000's)		.999 (.996, 1.002)		.999 (.995, 1.002)
Constant	.014***	.049***	.015***	.048***
-2 log likelihood	14460.505	13348.419	14419.712	13339.654
Model χ^2	181.220***	356.740***	222.014***	365.505***

Table 9. Logistic Regression results for present-day (2010) conditions around existing CFPPs.

Table 9 contains logistic regression results applying the 50% areal containment distance-based methods. Models include racial and socioeconomic variables using the 2010 Census for all existing CFPPs.

For CFPPs sited between 1945 and 1954 (Table 10), percent minority (Model 1) and percent Black (Model 3) were statistically significant predictors of facility siting using the 1950 Census. However, the odds ratio is under 1.0, indicating that white populations were more likely to live near siting locations of CFPPs. Likewise, when socioeconomic variables were added, percent minority and percent Black populations remained significant in the unexpected direction. Percent with a 4-year college degree was statistically significant in the unexpected direction. This is consistent with the descriptive results (Table 7). These results indicate little evidence for disparate siting, which is consistent with results found by Saha and Mohai (2005) for hazardous waste TDSF siting in the pre-environmental movement era. Mean property values and percent employed in white collar occupations are statistically significant in the expected direction (tracts with relatively low housing values and low percentage employed in such occupations are more likely to be near a CFPP), which lends mixed support for the market dynamics explanations. These variables are indicative of the market dynamics explanation as they lend support for hypotheses that industries seek low cost scenarios in facility siting, such as cheap land and more skilled unskilled labor.

Variables	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)	Model 4, OR (95% CI)
CFPPs sited 1945 - 1954 ***1950 Census***				
% Minority	.945** (.907, 984)	.824*** (.738, .921)		
% Black			.951** (.917, .987)	.847*** (.767, .936)
% Hispanic				
% Asian American, Pacific Islander				
% with college degree		1.087** (1.022, 1.156)		1.080* (1.015, 1.148)
% in white collar occupations		.954*** (.928, .981)		.956*** (.930, .982)
median housing value		.853** (.762, .956)		.860** (.768, .963)
mean family income ($1,000's)				
Constant	.010***	.307*	.010***	.260**
-2 log likelihood	1123.1	880.455	1125.752	885.648
Model χ^2	22.564***	74.663***	19.912***	69.470***

Table 10. Logistic Regression results for CFPPs sited between 1945 and 1954.

Table 10 contains logistic regression results applying the 50% areal containment distance-based methods. Models include racial and socioeconomic variables using the 1950 Census.

For CFPPs sited between 1955 and 1964 (Table 11), percent minority (Model 1) and percent Black (Model 3) were not statistically significant predictors of plant siting using the 1960 Census, and they remained so after including socioeconomic variables in the models (Model 2 and 4). In fact, percent with a 4-year college degree, in the expected direction, was the only statistically significant predictor of plant siting for this time period, providing little evidence overall for the racially disparate siting and market dynamics explanations. This is consistent with the descriptive results in this study and the descriptive results found by Saha and Mohai (2005) for TSDF siting in the pre-environmental movement era.

Variables	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)	Model 4, OR (95% CI)
CFPPs sited 1955 - 1964				
1960 Census				
% Minority	1.004 (.998, 1.010)	.994 (.987, .1002)		
% Black			1.005 (.999, 1.011)	.995 (.988, 1.003)
% Hispanic				
% Asian American, Pacific Islander				
% with college degree		.913** (.855, .975)		.910** (.852, .972)
% in white collar occupations		.982 (.962, 1.003)		.984 (.964, .972)
median housing value				
mean family income ($1,000's)				
Constant	.006***	.019***	.006***	.018***
-2 log likelihood	1652.153	1568.603	1651.237	1569.614
Model χ^2	1.418	58.045***	2.334	57.035

Table 11. Logistic Regression results for CFPPs sited between 1955 and 1964.

Table 11 contains logistic regression results applying the 50% areal containment distance-based methods. Models include racial and socioeconomic variables using the 1960 Census.

When examining the results for CFPPs sited between 1964 and 1975 (Table 12), percent minority (Model 1) and percent Black and percent Hispanic (Model 3), were statistically significant predictors of plant siting using the 1970 Census. When socioeconomic variables were entered into the equations, percent minority and percent Black remained statistically significant predictors while percent Hispanic did not, however the odds ratios under one indicated that the prediction moved to be in the unexpected direction (i.e. tracts with relatively higher percentages of Hispanic populations are *less* likely to be near a CFPP). Percent with college degrees were not significant predictors, while percent in white collar occupations and mean property value were significant predictors in the expected directions. Although both the logistic regression and the descriptive analyses reflected racial disparities around CFPP siting between 1964 and 1975, Models 2 and 4 found that when factoring socioeconomic variables into the equations, racial disparities were no longer significant or went in the unexpected direction, indicating that racial disparities in CFPP siting may be a reflection of the socioeconomic conditions of racial groups or interactions among the variables. Results of this study indicate that racial disparities around CFPP siting existed in this time period, but the reason they existed may be intertwined with stronger socioeconomic predictors. For example, minority groups may be less likely to have high-skilled jobs and more likely to live in places with lower property values.

Variables	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)	Model 4, OR (95% CI)
CFPPs sited 1965 - 1974 *1970 Census*				
% Minority	1.007*** (1.003, 1.010)	.991*** (.987, .996)		
% Black			1.008*** (1.004, 1.011)	.991*** (.987, .995)
% Hispanic			1.015*** (1.009, 1.021)	.996 (.988, 1.003)
% Asian American, Pacific Islander				
% with college degree		.998 (.970, 1.028)		.998 (.970, 1.027)
% in white collar occupations		.984* (.972, .997)		.983* (.971, .996)
mean housing value (owner-occupied)		.837*** (.816, .858)		.835*** (.814, .857)
mean family income ($1,000's)		.982 (.959, 1.005)		.981 (.957, 1.005)
Constant	.008***	.239***	.007***	.264***
-2 log likelihood	3562.19	2785.089	3541.03	2794.72
Model χ^2	11.423***	428.144***	32.854***	418.513***

Table 12. Logistic Regression results for CFPPs sited between 1965 and 1974.

Table 12 contains logistic regression results applying the 50% areal containment distance-based methods. Models include racial and socioeconomic variables using the 1970 Census.

For CFPPs sited between 1975 and 1984, percent minority (Model 1) and percent Black, Hispanic, and Asian/Pacific Islander (Model 3) were not statistically significant predictors of CFPP siting using the 1980 Census. When socioeconomic variables were added into the equations, racial variables remained not significant. All socioeconomic variables were also not significant predictors of plant siting except for mean family income in the unexpected direction in Model 2. When looking at the descriptive analyses (Table 5 and 7), these results are not surprising as racial and socioeconomic characteristics are equal or close to equal within 3.0-miles and beyond 3.0-

miles for most variables in this siting time period. These results provide little evidence for either discriminatory siting or market dynamics explanations in this time period.

Variables	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)	Model 4, OR (95% CI)
CFPPs sited 1975 – 1984				
1980 Census				
% Minority	1.000 (.988, 1.012)	1.001 (.988, 1.013)		
% Black			1.006 (.996, 1.017)	1.008 (.996, 1.020)
% Hispanic			.825 (.668, 1.020)	.815 (.645, 1.031)
% Asian American, Pacific Islander			.827 (.524, 1.305)	.817 (.451, 1.480)
% with college degree		.950 (.889, 1.014)		.937 (.876, 1.001)
% in white collar occupations		1.036 (.994, 1.081)		1.039 (.997, 1.084)
mean housing value (owner-occupied)		.983 (.959, 1.007)		.997 (.972, 1.022)
mean family income ($1,000's)		1.026* (1.005, 1.047)		1.020 (.995, 1.045)
Constant	.001***	.000***	.001***	.000***
-2 log likelihood	519.293	453.748	492.798	439.19
Model χ^2	0.002	8.308	17.498***	22.866**

Table 13. Logistic Regression results for CFPPs sited between 1975 and 1984.

Table 13 contains logistic regression results applying the 50% areal containment distance-based methods. Models include racial and socioeconomic variables using the 1980 Census.

When CFPPs sited between 1985 and 1994 were examined using the 1990 Census (Table 14), percent minority (Model 1), percent Black, and percent Asian/ Pacific Islander (Model 3) were not statistically significant predictors of plant siting locations. Percent Hispanic (Model 3) was a statically significant predictor in the expected direction (based on Table 6 and 8, from 1985 onward, we would expect that little racial/ethnicity disparities exist and tracts with relatively higher percentages of nonwhite populations were less likely to be near a CFPP). When socioeconomic variables were entered, percent minority (Model 2) became a statistically significant predictor of plant location in the unexpected direction, which may be an indication of an interaction between race and class. In this model, percent with college degree and mean family income were significant predictors in the expected directions and percent in white collar occupations was a significant predictor in the unexpected direction, while mean housing value was not a significant predictor. Model 4 was consistent with Model 2, with percent Hispanic remaining the only significant race/ethnicity predictor. This is consistent with the descriptive analysis (Table 6 and 8) and provides some evidence for the sociopolitical explanation, but not market dynamic explanation in this time period.

Variables	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)	Model 4, OR (95% CI)
CFPPs sited 1985 - 1994				
1990 Census				
% Minority	.996 (.988, 1.004)	.990* (.982, .999)		
% Black			1.004 (.997, 1.011)	.998 (.990, 1.006)
% Hispanic			.917** (.867, .970)	.910*** (.859, 964)
% Asian American, Pacific Islander			1.005 (.969, 1.042)	1.007 (.974, 1.042)
% with college degree		.969* (.942, .997)		.969* (.941, .996)
% in white collar occupations		1.035** (1.013, 1.057)		1.033** (1.011, 1.055)
mean housing value (owner-occupied)		1.003 (.997, 1.009)		1.005 (.999, 1.012)
mean family income ($1,000's)		.961** (.933, 990)		.960** (.933, .988)
Constant	.002***	.002***	.002***	.003***
-2 log likelihood	1322.659	1258.787	1299.487	1237.067
Model χ^2	1.2	23.415***	24.372***	45.134***

Table 14. Logistic Regression results for CFPPs sited between 1985 and 1994.

Table 14 contains logistic regression results applying the 50% areal containment distance-based methods. Models include racial and socioeconomic variables using the 1990 Census.

For CFPPs sited between 1995 and 2004, outcomes appear more mixed than previously. Using the 2000 Census (Table 15), percent minority (Model 1), was a statistically significant predictor of plant siting in the expected direction. When socioeconomic variables were included (Model 2), percent minority remained a significant predictor in the expected direction. Percent with college degrees was a significant predictor in the expected direction, while percent in white collar occupations was a significant predictor in the unexpected direction, and mean housing value and mean family income were not significant predictors. For the models (3 and 4) with a racial variable breakdown, percent Black, percent Hispanic, and percent Asian / Pacific Islander were not statistically significant predictors of facility siting. When socioeconomic variables were included in the model (Model 4), percent with college degree and percent in white collar occupations were the only socioeconomic variables that were significant predictors of facility siting, although percent with white collar occupations was again in the opposite direction. These results, showing little evidence for racial disparities but some evidence for socioeconomic disparities as factors in siting decisions, are consistent with the descriptive analyses and evidence found by Saha and Mohai (2005) for time periods after the beginning of the environmental justice movement.

Variables	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)	Model 4, OR (95% CI)
CFPPs sited 1995 - 2004 ***2000 Census***				
% Minority	.797** (.665, .956)	.834* (.711, .979)		
% Black			.897 (.740, 1.086)	.881 (.716, 1.084)
% Hispanic			.873 (.653, 1.167)	.867 (.653,1.152)
% Asian American, Pacific Islander			.382 (1.09, 1.336)	.634 (.185, 2.168)
% with college degree		.890** (1.032, 1.137)		.901** (.831, .997)
% in white collar occupations		1.083*** (1.032, 1.137)		1.074*** (1.027, 1.123)
mean housing value (owner-occupied)		.995 (.976, 1.014)		.995 (.976, 1.013)
mean family income ($1,000's)		1.010 (.984, 1.076)		1.016 (.954, 1.082)
Constant	.001***	.000***	.001***	.000***
-2 log likelihood	190.22	35.823***	190.584	180.561
Model χ^2	22.894***	177.104	22.530***	32.367***

Table 15. Logistic Regression results for CFPPs sited between 1995 and 2004.

Table 15 contains logistic regression results applying the 50% areal containment distance-based methods. Models include racial and socioeconomic variables using the 2000 Census.

Finally, few statistically significant predictors were present when examining CFPPs sited between 2005 and 2012 using the 2010 Census (Table 16). In all four models, racial variables were not statistically significant predictors of plant siting. When socioeconomic variables were added into the models (Model 2 and 4), the only statistically significant predictor of CFPP siting was mean housing value in the expected direction. Thus, there is little evidence for disparate siting in this time period, but some evidence for the market dynamics explanation.

Variables	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)	Model 4, OR (95% CI)
CFPPs sited 2005 - 2010 *2010 Census*				
% Minority	.935 (.858, 1.019)	.934 (.869, 1.004)		
% Black			.970 (.904, 1.040)	.947 (.871, 1.029)
% Hispanic			.911 (.727, 1.141)	.911 (.750, 1.108)
% Asian American, Pacific Islander			.270 (.034, 2.170)	.559 (.087, 3.592)
% with college degree		.991 (.843, 1.166)		.997 (.845, 1.175)
% in white collar occupations		.977 (.863, 1.105)		.974 (.860, 1.103)
mean housing value (owner-occupied)		.959* (.923, .997)		.960* (.924, .998)
mean family income ($1,000's)		.996 (.908, 1.092)		1.000 (.915, 1.093)
Constant	.000***		.000***	0.151
-2 log likelihood	100.381	83.595	95.429	83.135
Model χ^2	5.421**	21.809***	10.373*	22.270**

Table 16. Logistic Regression results for CFPPs sited between 2005 and 2012.

Table 16 contains logistic regression results applying the 50% areal containment distance-based methods. Models include racial and socioeconomic variables using the 2010 Census.

In sum, although mean property values were statistically significant independent predictors of CFPPs sited near 1950, 1970, and 2010, they are not significant predictors for plants sited near 1980, 1990, and 2000. At the same time, the race variables were statistically significant independent predictors of CFPP siting in 1970 and were either not statistically significant or predicted in the unexpected direction for all time periods when controlling for mean property value and other socioeconomic variables. While some of these results present evidence for the market dynamic explanation for CFPP siting, they also support the claim that socioeconomic conditions are an important factor in predicting facility siting. While racial disparities were present in the siting of CFPPs in many time periods (Table 4 and 5), the results of the multivariate statistical analyses indicate that the racial disparities may be an outcome of worse socioeconomic conditions for minority groups.

This evidence is different than results yielded for the siting of hazardous waste TSDFs (Mohai and Saha 2015b), where race variables remained statistically significant throughout all decades, even when controlling for mean property value and other socioeconomic variables. These results may be due to shift of CFPPs being sited in growing western states with fewer minorities as well as in rural communities with low population density and tend to be more accepting of development (Powell 1984). There have been relatively fewer plants sited in recent decades, and fewer people living in host communities, which also suggests that there has been a trend of siting in more rural locations over time. Further, when conducting the regression analysis on the pooled set of facilities and using the 2010 Census, race variables nevertheless remained statistically significant independent predictors of CFPP locations after the socioeconomic variables were entered into the models. This could mean that the racial disparities widened after siting, suggesting the possibility of post-siting demographic change. The widening of racial disparities around TSDFs after siting is something that Mohai and Saha (2015) also found, therefore, further analysis of post-siting demographic changes around CFPPs should be considered.

It is important, again, to note that very few plants existed within tracted areas in the 1950 and 1960 Census while approximately half of plants sited near 1970 and 1980 were within tracted areas. As a result, the logistic regressions for plants sited within the 1950 and 1960 decades could be skewed.

CHAPTER 6: Summary & Conclusions

The purpose of this study was to determine if there are current (2010) racial and socioeconomic disparities around U.S. CFPPs and if so, whether such disparities were present at the time of siting. In particular, this study assessed whether there were differences in the patterns of disparate siting across decades prior to, during, and after the emergence of the modern environmental and environmental justice movements. Results showed present-day (2010) racial and socioeconomic disparities for existing CFPPs, and lent support for hypotheses that increased environmental awareness in the 1960's and 1970's, as well as increased environmental justice awareness and activism in the late 1980's onwards, influenced CFPP siting in communities of color, consistent with results found by prior studies for TSDFs (Saha and Mohai 2005; Mohai and Saha 2015b). Such differences may be a product of the emergence of state siting policies for power plants in the early 1970's, as well as a transition to facility siting in rural, western communities. Socioeconomic variables were consistently significant independent predictors of facility siting in time periods between 1945 and 1954, 1965 and 1974, and 1984 and 1995. These results, as well as possible explanations, are discussed further below.

Discussion

Overall, results indicate present-day (using the 2010 Census) racial and economic disparities within 3.0-miles of CFPP host communities that are greater than the disparities found by the NCAAP for 2000 (Wilson et al. 2011). This finding provides evidence for recent post-siting demographic change, and could be a result of further minority and low-income move in or economic decline in the mid-late 2000's.

While considering present-day populations, however, it is also important to take into account the siting date of CFPPs. As mentioned previously, new CFPPs, in particular, those sited after 1967, have stricter pollution control regulations than those sited prior, as granted by the CAA's grandfathering clause. In this study, 192 CFPPs out 367 (52%) were sited prior to 1967 (the cut off date for grandfathering in the CAA) and many of these plants are likely to pose relatively high health risks when compared to more recently built ones, which are more likely to be sited where larger proportions of whites reside. Host communities around grandfathered plants have greater racial/ethnic and socioeconomic disparities today when compared to host communities of CFPPs sited in more recent decades, suggesting an even greater burden on racial/ethnic minorities and the poor.

For host communities at the time of CFPP siting, racial/ethnic and socioeconomic disparities were not found for plants sited between 1945 and 1954. Racial/ethnic disparities were found only in host communities sited between 1955 and 1984, while various socioeconomic disparities were found from 1965 onward. Such results indicate that larger percentages of nonwhites may have been a factor in plant siting for decades during the environmental movement (1960's – 1980's), while low-socioeconomic status and educational attainment is a factor that has possibly contributed to siting decisions continued over time.

Furthermore, the large majority of CFPPs (73%) were sited during periods when poor and minority communities were believed to have been impacted by NIMBYism (1970's and 1980's), i.e., by vigorous opposition to facility siting in wealthier white communities serving to steer noxious facilities into poor and minority communities (Saha and Mohai 2005). This assessment is consistent with the arguments and findings of Saha and Mohai (2005) and others pertaining to hazardous waste TSDFs following the path of least political resistance. Additionally, findings of racial/ethnic siting disparities in earlier time periods (between 1955 and 1964 and 1965 and 1974), in particular, are consistent with hypotheses that racially discriminatory housing and lending policies, legal until the Fair Housing Act of 1968, may have resulted in racially segregated housing patterns with minority neighborhoods that could be easily targeted for the siting of new CFPPS and other locally unwanted land uses.

However, logistic regressions indicate that socioeconomic variables were more important predictors of plant siting throughout all time periods, lending support for both sociopolitical and market dynamics explanations as well. For example, findings of low mean property values and populations with low percentages of educational attainment, white-collar workers, and mean family income near CFPPs relative to persons beyond 3.0-miles of CFPPs, support hypotheses that industries have sought to site facilities in areas with low property values, cheap labor force, and populations less likely to have the social capital and resources to generate opposition. While racial disparities are evident around CFPPs at the time of siting during the emergence of the environmental movement, this study provides evidence that racial disparities may be a result of underlying socioeconomic differences between white and nonwhite communities. Further analyses examining what factors contributed to varying socioeconomic conditions between white and nonwhite populations should be considered in future studies.

This study supports conclusions originally made by Saha and Mohai (2005) that historical context may influence disparate siting. In particular, evidence of racial/ethnic and economic disparities beginning in 1970, but not prior, are consistent with Saha and Mohai (2005)'s argument that growing environmental concern, public opposition, and changes in environmental policy in the early 1960's and 1970's prompted CFPP sitings to follow the 'path of least resistance'. Similarly, smaller nonwhite populations and better economic conditions closer to CFPPs in the 1950's may be explained by Taylor (2009)'s discussion on how facility managers, who were most often white, were often given priority housing closer to their facilities prior to environmental awareness and white flight and an extensive highway system to enable long-distance commuting to work. Further, the decrease in racial/ethnic disparities around CFPPs sited from 1985 onward is consistent with the emergence of the environmental justice movement in the early 1980's, as well as the findings of the Carrell Report, in which rural communities were among those found less likely to resist LULU siting in 1984, while growing environmental justice awareness prompted communities of color to oppose such facilities in their neighborhoods (Powell 1984). This observation is similar to that found by Saha and Mohai (2005) and Mohai and Saha (2015b) for hazardous waste TSDFs.

Conclusions

This longitudinal analysis is consistent with local and national studies using a distance-based approach in revealing temporal differences in the community demographics around CFPPs at or near the time of siting (Pastor, Sadd, and Hipp (2001), Saha and Mohai (2005), and Mohai and Saha (2015b). Such differences seem to correspond with patterns marking historical changes in environmental awareness, attitude, and policies, as well as industry learning of the path of least resistance, indicating that the environmental movement and increased environmental protections did not necessarily benefit all, but rather placed the largest proportion of environmental burdens on our nation's most vulnerable populations. However, unlike prior studies using the distance-based approach focused on hazardous waste TSDFs, this study found evidence that socioeconomic variables were more important independent predictors in CFPP siting than racial/ethnic variables.

Further research must be conducted in order to evaluate factors that could contribute to differences in CFPP siting disparities across decades and differences in CFPP siting when compared to other LULUs. For example, further examination of geographic location (urban vs. rural) may explain the varying significance of socioeconomic and racial variables. As populations, energy demand, and environmental awareness expanded throughout time, it is possible that older CFPPs continued to operate while new CFPPs (1990's onward) were more likely to be built in rural communities with more land and natural resources. Such communities often had fewer people to oppose them, and were likely to seek economic development opportunities from CFPPs (Powell 1984). As urban communities often have larger nonwhite populations than rural communities, the distribution of plants across landscape may help explain differences in racial/ethnic disparities over time. Comparing the siting in urban and rural host-communities was not within the scope of this study, yet new longitudinal studies that take into account urban and rural divides would help to shed light on this hypothesis.

Likewise, as suggested by previous studies, more examination is required on the distribution of a wider variety of LULUs. Both cross-sectional and longitudinal studies are needed to firmly establish and explore the historical context of siting, as well as the subtle and overt factors that contribute to it (Mohai and Saha 2015b, Saha and Mohai 2005). In particular, further research is needed to analyze the factors that contributed to how such racial disparities were created and sustained. For example, a deeper analysis is needed on how the legality of discriminatory practices such as redlining and other discriminatory housing or zoning policies throughout the early-mid twentieth century contributed to the siting of CFPPs and other hazardous facilities.

Likewise, further analyses into the differences in state and local zoning, land use regulations and economic development policy, could be carried out. Similar to the urban and rural divide discussed above, state incentives for industry to do business in their borders may have influenced CFPP siting and in turn, community composition around plants. In particular, scholars have argued whether decentralization of regulation, like that of power plant siting in the early 1970's, led states to a "race to the bottom". This theory asserts that states are primarily concerned with economic development, and when faced with interstate competition, they will reduce environmental regulation to gain economic advantage over nearby states (Konisky 2007; Rabe 2010). In the context of coal, such regulatory competition could have influenced industry officials to site a facility in a particular state with more economic incentives or less regulatory burdens. As a result, such incentives, fueled by state regulatory burdens or lack thereof, may be an additional sociopolitical factor influencing siting decisions.

Further research could also explore post-siting demographic change around CFPPs, smaller host-communities (1.0-mile radii), and an expanded set of population demographics, such as nationality and immigration status. For example, it is possible that the varying results of this study with those of Mohai and Saha (2015b) might also be an outcome of using a large radius to define the neighborhood around plants (3.0-miles vs. 3.0 km). In this study, the 3.0-mile radius was chosen because of the presumed wider impact of CFPPs and also to be more consistent with the NAACP study, however, a smaller radius might lead to results more similar to prior longitudinal environmental justice studies on hazardous waste TSDFs (Mohai and Saha 2015b). Thus, future studies should examine the impact of the outcomes of using varying distances around the plants.

The historical patterns of disparate siting of CFPPs found in this study demand careful investigation of both environmental movements and environmental policies. As the popularity of social movements increases and the environmental regulation debate becomes more prominent, historical context indicates a need for constant evaluation of for whom and with whom social movements are fighting, and how subsequent policies impact the most marginalized communities. In particular, as we prepare for CFPP decommissioning due to competition with natural gas and the development of new energy sources, government and industry policies must consider equitable transition planning and siting to reduce racial and socioeconomic disparities.

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APPENDIX I

Census Data Sources by Census Year and Geographic Area

Year	*Variable*	*Geographic Areas*	*Source**	
2010	Total population	tracts	[a]	Table B02001: Total Population
2010	Black, Hispanic, Asian, and White population	tracts	[a]	Table B03002: Total Population; Hispanic or Latino Origin by Race
2010	% Black, % Hispanic, % Asian and % Nonwhite	tracts	Calculated [a]	from Table B03002: Total Population; Hispanic or Latino Origin by Race
2010	Aggregate family income	tracts	[a]	Table B19128: Families; Aggregate Family Income in the Past 12 months
2010	Total number of families	tracts	[b]	Table P 35: Families
2010	Mean family income	tracts	Calculated [a,b]	from Table B19128: Families; Aggregate Family Income in the Past 12 months and Table P 35: Families
2010	Total population 16 years and over	tracts	[a]	Table C24010: Civilian employed population 16 years and over
2010	Occupation for persons 16 years and over	tracts	[a]	Table C24010: Civilian employed population 16 years and over; Sex by Occupation
2010	% blue-collar workers	tracts	Calculated [a]	from Table C24010: Civilian employed population 16 years and over; Sex by Occupation
2010	% white-collar workers	tracts	Calculated [a]	from Table C24010: Civilian employed population 16 years and over; Sex by Occupation
2010	Total population 25 years and over	tracts	[a]	Table B15002: Population 25 years and over
2010	% high school graduates	tracts	Calculated [a]	from Table B15002: Population 25 years and over; Sex by Educational Attainment
2010	% college graduates	tracts	Calculated [a]	from Table B15002: Population 25 years and over; Sex by Educational Attainment
2010	Aggregate Value of Owner-Occupied Housing Units	tracts	[a]	Table B25082: Owner-occupied housing units; Aggregate Value by Mortgage Status
2010	Number of Owner-Occupied Housing Units	tracts	[a]	Table B25003: Occupied housing units by Tenure; Owner-Occupied
2010	mean housing value (owner-occupied units)	tracts	Calculated [a]	from Table B25082: Owner-occupied housing units; Aggregate Value by Mortgage Status and Table B25003: Occupied housing units by Tenure; Owner-Occupied

Census Data Sources by Census Year and Geographic Area *(continued)*

Year	*Variable*	*Geographic Areas*	*Source**	
2000	Total population	tracts	[c]	Table NP001A: Persons
2000	Black, Hispanic, Asian, and White population	tracts	[c]	Table NP008A: Persons; Persons by Hispanic or Latino Origin and Not Hispanic or Latino by Race
2000	% Black, % Hispanic % Asian, and % Nonwhite	tracts	Calculated [c]	from Table NP008A: Persons; Persons by Hispanic or Latino Origin and Not Hispanic or Latino by Race
2000	Aggregate family income	tracts	[d]	Table NP978A: Families; Total Aggregate Family Income in 1999
2000	Total number of families	tracts	[c]	Table NP031A: Families
2000	Mean family income	tracts	Calculated [c,d]	from Table NP978A: Families; Total Aggregate Family Income in 1999; Table NP031A: Families
2000	Total population 16 years and over	tracts	[d]	Table NP050A: Employed Civilian Persons 16 years and over
2000	Occupation for persons 16 years and over	tracts	[d]	Table NP050A: Employed Civilian Persons 16 years and over; Sex by Occupation Type
2000	% blue-collar workers	tracts	Calculated [d]	from Table NP050A: Employed Civilian Persons 16 years and over; Sex by Occupation Type
2000	% white-collar workers	tracts	Calculated [d]	from Table NP050A: Employed Civilian Persons 16 years and over; Sex by Occupation Type
2000	Total population 25 years and over	tracts	[d]	Table NP 037C: Persons 25 years and over
2000	% high school graduates	tracts	Calculated [d]	from Table NP 037C: Persons 25 years and over; By Sex by Educational Attainment
2000	% college graduates	tracts	Calculated [d]	from Table NP 037C: Persons 25 years and over; By Sex by Educational Attainment
2000	Aggregate Value of Owner-Occupied Housing Units	tracts	[d]	Table NH 086A: Owner-occupied housing units; Aggregate Value
2000	Number of Owner-Occupied Housing Units	tracts	[c]	Table NH 004B: Occupied housing units by Tenure; Owner-Occupied
2000	mean housing value (owner-occupied units)	tracts	Calculated [c,d]	from Table NH 086A: Owner-occupied housing units; Aggregate Value and Table NH 004B: Occupied housing units by Tenure; Owner-Occupied

Census Data Sources by Census Year and Geographic Area (continued)

Year	*Variable*	*Geographic Areas*	*Source**	
1990	Total population	tracts	[e]	Table NP 1: Persons
1990	Black, Hispanic, Asian, and White population	tracts	[e]	Table NP 10: Persons; Hispanic Origin by Race
1990	% Black, % Hispanic, % Asian, and % Nonwhite	tracts	Calculated [e]	from Table NP 10: Persons; Hispanic Origin by Race
1990	Aggregate family income	tracts	[f]	Table NP 4: Families
1990	Total number of families	tracts	[f]	Table NP 108: Families; Aggregate Family income in 1989
1990	Mean family income	tracts	Calculated [f]	from Table NP4 and Table NP 108: Families; Aggregate Family income in 1989
1990	Total population 16 years and over	tracts	[f]	NP 78: Employed persons 16 years and over
1990	Occupation for persons 16 years and over	tracts	[f]	NP 78: Employed persons 16 years and over by Occupation
1990	% blue-collar workers	tracts	Calculated [f]	from NP 78: Employed persons 16 years and over by Occupation
1990	% white-collar workers	tracts	Calculated [f]	from NP 78: Employed persons 16 years and over by Occupation
1990	Total population 25 years and over	tracts	[f]	Table NP 57: Persons 25 years and over
1990	% high school graduates	tracts	Calculated [f]	from Table NP 57: Persons 25 years and over; Educational Attainment
1990	% college graduates	tracts	Calculated [f]	from Table NP 57: Persons 25 years and over; Educational Attainment
1990	Aggregate Value of Owner-Occupied Housing Units	tracts	[e]	Table NH 24: Specified owner-occupied housing units; Aggregate Value
1990	Number of Owner-Occupied Housing Units	tracts	[e]	Table NH 3: Occupied housing units by Tenure; Owner-Occupied
1990	mean housing value (owner-occupied units)	tracts	Calculated [e]	from Table NH 24: Specified owner-occupied housing units; Aggregate Value and Table NH 3: Occupied housing units by Tenure

***Census Data Sources by Census Year and Geographic Area** (continued)*

Year	*Variable*	*Geographic Areas*	*Source**	
1980	Total population	tracts; counties	[g]	Table NT 126: Persons
1980	Black, Hispanic, Asian, and White population	tracts; counties	[g]	Table NT 7 and 9B: Persons by Race and Persons of Spanish Origin by Race
1980	% Black, % Hispanic, % Asian and % Nonwhite	tracts; counties	Calculated [g]	from Table NT 7 and 9B: Persons by Race and Persons of Spanish Origin by Race
1980	Aggregate family income	tracts; counties	[h]	Table NT 77A: Aggregate Family Income in 1979
1980	Total number of families	tracts; counties	[h]	Table NT 9: Families
1980	Mean family income	tracts; counties	Calculated [h]	from Table NT 77A: Aggregate Family Income in 1979 and Table NT 9: Families
1980	Total population 16 years and over	tracts; counties	[h]	Table NT 66: Employed Persons 16 years and over
1980	Occupation for persons 16 years and over	tracts; counties	[h]	Table NT 66: Employed Persons 16 years and over by Occupation
1980	% blue-collar workers	tracts; counties	Calculated [h]	from Table NT 66: Employed Persons 16 years and over by Occupation
1980	% white-collar workers	tracts; counties	Calculated [h]	from Table NT 66: Employed Persons 16 years and over by Occupation
1980	Total population 25 years and over	tracts; counties	[h]	Table NT 48A: Persons 25 years and over
1980	% high school graduates	tracts; counties	Calculated [h]	from NT 48A: Persons 25 years and over by Years of School Completed
1980	% college graduates	tracts; counties	Calculated [h]	from NT 48A: Persons 25 years and over by Years of School Completed
1980	Aggregate Value for Owner-Occupied Housing Units	tracts;	[g]	Table NT 40: Aggregate Value and Price Asked by Occupancy Status; Owner-Occupied Units
1980	Number of Owner-Occupied Housing Units	tracts;	[g]	Table NT 41: Occupancy Status; Owner-Occupied Units
1980	Mean housing value (owner-occupied units)	tracts;	Calculated [g]	from Table NT 40: Aggregate Value and Price Asked by Occupancy Status; Owner-Occupied Units and NT 41: Occupancy Status; Owner-Occupied Units

Census Data Sources by Census Year and Geographic Area *(continued)*

Year	*Variable*	*Geographic Areas*	*Source**	
1970	Total Population	tracts; counties	[i]	Table NT 126: Persons
1970	Black and White population	tracts; counties	[i]	Table NT 105: Persons by Race
1970	% Black and % Nonwhite	tracts; counties	Calculated [i]	from Table NT 105: Persons by Race
1970	Hispanic population		[j]	Table NT 24: Persons by Spanish Indicator
1970	% Hispanic	tracts; counties	Calculated [j]	from Table NT 24: Persons by Spanish Indicator
1970	Aggregate family income	tracts; counties	[j]	Table NT 1: Families; Aggregate Family Income
1970	Total number of families	tracts; counties	[k]	Table NT 27: Occupied Units; Household Type for Occupied Units
1970	Mean family income	tracts; counties	Calculated [j,k]	from Table NT 1: Families; Aggregate Family Income;
1970	Total population 16 years and over	tracts; counties	[j]	Table NT 58: Employed Persons 16 years and over
1970	Occupation by persons 16 years and over	tracts; counties	[j]	Table NT 58: Employed Persons 16 years and over by Occupation
1970	% blue-collar workers	tracts; counties	Calculated [j]	from Table NT 58: Employed Persons 16 years and over by Occupation
1970	% white-collar workers	tracts; counties	Calculated [j]	from Table NT 58: Employed Persons 16 years and over by Occupation
1970	Total population 25 years and over	tracts; counties	[i]	Table NT 114: Persons 25 years and over
1970	% high school graduates	tracts; counties	Calculated [i]	from Table NT 114: Persons 25 years and over by Years of School Completed
1970	% college graduates	tracts; counties	Calculated [i]	from Table NT 114: Persons 25 years and over by Years of School Completed
1970	Aggregate Value for Owner-Occupied Housing Units	tracts	[k]	Table NT1A:Aggregate Value for Occupied Units; Owner-Occupied Units
1970	Number of Owner-Occupied Housing Units	tracts	[k]	Table NT 12A: Occupied Units by Tenure; Owner-Occupied Units
1970	Mean housing value (owner-occupied units)	tracts	Calculated [k]	from Table NT1A:Aggregate Value for Occupied Units; Owner-Occupied Units and Table NT 12A: Occupied Units by Tenure; Owner-Occupied Units

Census Data Sources by Census Year and Geographic Area *(continued)*

Year	*Variable*	*Geographic Areas*	*Source**	
1960	Total Population	tracts; counties	[1]	Table NBT 4: Persons
1960	Black and White population	tracts; counties	[1]	Table NBT 4: Persons; Population by Race
1960	% Black, and % Nonwhite	tracts; counties	Calculated [1]	from Table NBT 4: Persons; Population by Race
1960	Employed population 14 years and over	tracts	[1]	Table NBT 34: Employed Persons
1960	Occupation by persons 14 years and over	tracts	[1]	Table NBT 47: Employed Persons; Employed Population by Sex by Occupation
1960	% blue-collar workers	tracts	Calculated [1]	from Table NBT 47: Employed Persons; Employed Population by Sex by Occupation
1960	% white-collar workers	tracts	[1]	from Table NBT 47: Employed Persons; Employed Population by Sex by Occupation
1960	Total population 25 years and over	tracts	[1]	Table NT 30: Persons 25 years and Over
1960	% high school graduates	tracts	Calculated [1]	from Table NT 30: Persons 25 years and Over; 25 years and over by Years of School Completed
1960	% college graduates	tracts	Calculated [1]	from Table NT 30: Persons 25 years and Over; 25 years and over by Years of School Completed

Census Data Sources by Census Year and Geographic Area *(continued)*

Year	*Variable*	*Geographic Areas*	*Source**	
1950	Total Population	tracts; counties	[m]	Table NT 1: Persons
1950	Black and White population	tracts; counties	[m]	Table NT 2: Persons
1950	% Black, and % nonwhite	tracts; counties	Calculated [m]	from Table NT 2: Persons; Population by Race
1950	Employed population 14 years and over	tracts; counties	[m]	Table NT 27: Employed Persons
1950	Occupation by persons 14 years and over	tracts; counties	[m]	Table NT 27: Employed Persons; Employed Population by Sex by Major Occupational Group
1950	% blue-collar workers	tracts; counties	Calculated [m]	from Table NT 27: Employed Persons; Employed Population by Sex by Major Occupational Group
1950	% white-collar workers	tracts; counties	Calculated [m]	from Table NT 27: Employed Persons; Employed Population by Sex by Major Occupational Group
1950	Total population 25 years and over	tracts; counties	[m]	Table NT 12: Persons 25 years and older
1950	% high school graduates	tracts; counties	Calculated [m]	from NT 12: Persons 25 years and older; Years of School Completed
1950	% college graduates	tracts; counties	Calculated [m]	from NT 12: Persons 25 years and older; Years of School Completed
1950	median housing value	tracts	[m]	Table NT 42: 1-Dwelling Unit Structures Reporting Value; Median Housing Value

* All tabular data was retrieved from the Minnesota Population Center National Historical Geographic Information Systems Database. Source code

a	2010 American Community Survey: 5-year Data	h	1980 Census: STF 3 - Sample-Based Data
b	2010 Census: SF 1a - P & H Tables	i	1970 Census: Count 4pa - Sampled-Based Population Data
c	2000 Census: SF 1a - 100% Data	j	1970 Census: Count 4pb - Sampled-Based Population Data with Race/Ethnicity Breakdown
d	2000 Census: SF 3a - Sample-Based Data	k	1970 Census: Count 3 - 100% Data
e	1990 Census: SF 1 - 100% Data	l	1960 Census: Population & Housing Data
f	1990 Census: STF 3 - Sample-Based Data	m	1950 Census: Population & Housing Data
g	1980 Census: STF 1 - 100% Data		

Census Variable Definitions, 1950, 1960, 1970, 1980, 1990, 2000, and 2010

<u>1950</u>

Percent minority:

Percent Black or African American: Number of "Negros" divided by number of persons with race reported.

Percent white: Number of "White" divided by number of persons with race reported.

Percent minority / non white: Number of "Whites", subtracted from number of persons with race reported, divided by number of persons with race reported.

Percent with a (four-year) college degree: Number of persons 25 years old and over with a four-year college degree divided by number of persons 25 years and over.

Percent employed in executive, management or professional occupations: Sum of persons 14 years old and over employed, (1) as professional, technical, and kindred workers, or (2) as managers and administrators, divided by number of employed persons 14 years old and over.

Percent employed in precision, production or labor occupations: Sum of persons 14 years old and over employed as, (1) craftsmen and kindred workers, or as (2) operatives, except transport, (3) transportation equipment operatives, or (4) laborers, except farm, divided by number of employed persons 14 years old and over.

Mean property value: Mean Housing Value of 1-Dwelling Unit Structures Reporting Value; Median Housing Value

<u>1960</u>

Percent Black or African American: Number of "Negros" divided by number of persons with race reported.

Percent white: Number of "White", divided by number of persons with race reported.

Percent minority / non white: Number of "Whites", subtracted from number of persons with race reported, divided by number of persons with race reported.

Percent with a (four-year) college degree: Number of persons 25 years old and over with a four-year college degree divided by number of persons 25 years and over.

Percent employed in executive, management or professional occupations: Sum of persons 16 years old and over employed, (1) as professional, technical, and kindred workers, or (2) as managers and administrators, divided by number of employed persons 14 years old and over.

Percent employed in precision, production or labor occupations: Sum of persons 14 years old and over employed as, (1) craftsmen and kindred workers, or as (2) operatives, except transport, (3) transportation equipment operatives, or (4) laborers, except farm, divided by number of employed persons 14 years old and over.

<u>1970 Census</u>

Percent Black or African American: Number of "Negros" divided by number of persons with race reported.

Percent Hispanic: Number of persons classified in any of the five Spanish categories of the question on "origin or descent" divided by number of persons with race reported.

Percent white: Number of "White", divided by number of persons with race reported.

Percent minority / non white: Number of "Whites", subtracted from number of persons with race reported, divided by number of persons with race reported.

Percent with a (four-year) college degree: Number of persons 25 years old and over with a four-year college degree divided by number of persons 25 years and over.

Percent employed in executive, management or professional occupations: Sum of persons 16 years old and over employed, (1) as professional, technical, and kindred workers, or (2) as managers and administrators, divided by number of employed persons 16 years old and over.

Percent employed in precision, production or labor occupations: Sum of persons 16 years old and over employed as, (1) craftsmen and kindred workers, or as (2) operatives, except transport, (3) transportation equipment operatives, or (4) laborers, except farm, divided by number of employed persons 16 years old and over.

Mean property value: Aggregate value of owner occupied housing units for which values were tabulated divided number of owner-occupied housing units for which value was tabulated, expressed in thousands of dollars.

Mean family income: Aggregate family income divided by Number of Families.

<u>1980 Census</u>

Percent black or African American: Number of blacks divided by number of persons.

Percent Hispanic: Sum of Mexicans, Puerto Ricans, Cubans and "Other Spanish" divided by number of persons.

Percent Asian/Pacific Islander: Number of Japanese, Chinese, Filipinos, Koreans, Asian Indians, Vietnamese, Hawaiians, Guamanians, Samoans and Other Asians or Pacific Islanders divided by number of persons.

Percent white: Number of "White", divided by total number of persons of any race.

Percent minority / non white: Number of "Whites", subtracted from number of persons with race reported, divided by number of persons with race reported.

Percent with a (four-year) college degree: Number of persons with a four-year college degree divided by number of persons 25 years old and over.

Percent employed in executive, management or professional occupations: Sum of persons 16 years old and over employed in, (1) executive, administrative and managerial, or (2) professional specialty occupations, divided by the number of employed persons 16 years old and over.

Percent employed in precision, production or labor occupations: Sum of persons 16 years old and over employed, (1) in precision, production, craft, or repair occupations, (2) as machine operators, assemblers or inspectors, (3) in transportation and material moving occupations, or (4) as handlers, equipment cleaners, helpers or operators, divided by number of employed persons 16 years old and over.

Mean property value: Aggregate Value for Owner-Occupied Units divided by Owner-Occupied Units

Mean family income: Aggregate family income divided by Number of Families.

<u>1990 Census</u>

Percent black or African American: number of African Americans alone divided by number of persons by Hispanic Origin by Race.

Percent Hispanic: number of persons of Hispanic origin divided by number of persons by Hispanic Origin by Race.

Percent Asian/Pacific Islander: number of Asian Americans or Pacific Islander divided by number of persons.

Percent white: number of "non-Hispanic White", divided by the total number of persons by Hispanic Origin by Race.

Percent minority / non white: number of "non-Hispanic White" subtracted by the total number of persons by Hispanic Origin by Race, divided by by the total number of persons by Hispanic Origin by Race.

Percent with a (four-year) college degree: number of persons 25 years old and over with a four-year college degree divided by number of persons 25 years old and over.

Percent employed in executive, management or professional occupations: Sum of persons 16 years old and over employed in, (1) executive, administrative, and managerial, or (2) professional specialty occupations, divided by number of employed persons 16 years old and over.

Percent employed in precision, production or labor occupations: Sum of persons 16 years old and over belonging employed: (1) in precision, production, craft, and repair, (2) as machine operators, assemblers, or inspectors, (3) as transportation and material moving operators, or (4) as handlers, equipment cleaners, helpers, and operators, divided by number of employed persons 16 years old and over.

Mean property value: Aggregate value of specified owner-occupied housing units divided by number of specified owner-occupied housing units, expressed in thousands of dollars.

Mean family income: Aggregate family income divided by Number of Families.

<u>2000 Census</u>

Percent black or African American: number of African Americans alone divided by number of persons.

Percent Hispanic: number of persons of Hispanic origin divided by number of persons.

Percent Asian/Pacific Islander: Sum of number of Asians alone and Native Hawaiian and Other Pacific Islanders alone, divided by number of persons.

Percent white: number of "non-Hispanic White", divided by the total number of persons by Hispanic Origin by Race.

Percent minority / non white: number of "Whites" subtracted by by the total number of persons by Hispanic Origin by Race, divided by by the total number of persons by Hispanic Origin by Race.

Percent with a (four-year) college degree: number of persons 25 years old and over with a four-year college degree divided by number of persons 25 years old and over.

Percent employed in executive, management or professional occupations: number of persons employed in management, professional and related occupations divided by number of employed persons 16 years old and over.

Percent employed in precision, production or labor occupations: Sum of number of persons employed persons in, (1) construction, extraction, and maintenance, or (2) production, transportation, and material moving occupations, divided by number of employed person 16 years old and over.

Mean property value: Aggregate value of owner-occupied housing units, divided by number of specified owner-occupied housing units, expressed in thousands of dollars.

Mean family income: Aggregate family income divided by Number of Families.

<u>2010</u>

Percent black or African American: number of African Americans alone divided by number of persons.

Percent Hispanic: number of persons of Hispanic origin divided by number of persons by Hispanic Origin by Race.

Percent Asian/Pacific Islander: Sum of number of Asians alone and Native Hawaiian and Other Pacific Islanders alone, divided by number of persons.

Percent white: number of "non-Hispanic White", divided by the total number of persons by Hispanic Origin by Race.

Percent minority / non white: number of "Whites" subtracted by by the total number of persons by Hispanic Origin by Race, divided by by the total number of persons by Hispanic Origin by Race.

Percent with a (four-year) college degree: number of persons 25 years old and over with a four-year college degree divided by number of persons 25 years old and over.

Percent employed in executive, management or professional occupations: number of persons employed in management, professional and related occupations divided by number of employed persons 16 years old and over.

Percent employed in precision, production or labor occupations: Sum of number of persons employed persons in, (1) construction, extraction, and maintenance, or (2) production, transportation, and material moving occupations, divided by number of employed person 16 years old and over.

Mean property value: Aggregate value of owner-occupied housing units, divided by number of specified owner-occupied housing units, expressed in thousands of dollars.

Mean family income: Aggregate family income divided by Number of Families.

APPENDIX II

Model Variance Inflation Factors (VIF) for 3.0-mile host community demographics
Dependent variable for all: Location; 1 – within 3.0-miles; 0 – beyond 3.0-miles

Present-Day (2010) Existing CFPPs

Model 1		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	minperc	1.000	1.000

Model 2		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	minperc	.806	1.241
	colperc	.196	5.091
	properc	.234	4.268
	meanhv1000	.469	2.132
	mfinc1000	.448	2.231

Model 3		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	blackperc	.983	1.017
	hisperc	.989	1.011
	asnperc	.984	1.016

Model 4		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	blackperc	.898	1.113
	hisperc	.779	1.284
	asnperc	.791	1.264
	colperc	.194	5.154
	properc	.230	4.354
	meanhv1000	.412	2.426
	mfinc1000	.443	2.258

CFPPs sited 1945 – 1954 (1950 Census)

Model 1		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	minperc	1.000	1.000

Model 2		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	minperc	.713	1.403
	colperc	.296	3.375
	properc	.240	4.173
	medhv1000	.367	2.722

Model 3		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	blackperc	1.000	1.000

Model 4		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	blackperc	.716	1.397
	colperc	.297	3.367
	properc	.240	4.163
	medhv1000	.367	2.722

CFFPs sited 1955 – 1964 (1960 Census)

Model 1		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	minperc	1.000	1.000

Model 2		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	minperc	.771	1.297
	colperc	.309	3.235
	properc	.266	3.753

Model 3		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	blackperc	1.000	1.000

Model 4		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	blackperc	.776	1.289
	colperc	.311	3.219
	properc	.269	3.723

CFPPs sited 1965 – 1975 (1970 Census)

Model 1		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	minperc	1.000	1.000

Model 2		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	minperc	.752	1.330
	colperc	.272	3.670
	properc	.262	3.821
	meanhv1000	.447	2.237
	mfinc1000	.992	1.008

Model 3		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	blackperc	.999	1.001
	hisperc	.999	1.001

Model 4		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	blackperc	.725	1.379
	hisperc	.925	1.081
	colperc	.271	3.690
	properc	.254	3.930
	meanhv1000	.445	2.250
	mfinc1000	.991	1.009

CFPPs sited 1975 – 1984 (1980 Census)

Model 1		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	minperc	1.000	1.000

Model 2		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	minperc	.792	1.263
	colperc	.249	4.016
	properc	.277	3.616
	meanhv1000	.378	2.649
	mfinc1000	.340	2.940

Model 3		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	blackperc	.993	1.007
	hisperc	.989	1.011
	asnperc	.985	1.015

Model 4		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	blackperc	.838	1.194
	hisperc	.875	1.143
	asnperc	.876	1.141
	colperc	.248	4.025
	properc	.276	3.629
	meanhv1000	.330	3.027
	mfinc1000	.334	2.996

CFPPs sited 1985 – 1994 (1990 Census)

Model 1		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	minperc	1.000	1.000

Model 2		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	minperc	.865	1.156
	colperc	.226	4.427
	properc	.261	3.825
	meanhv1000	.378	2.644
	mfinc1000	.284	3.525

Model 3		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	blackperc	.994	1.006
	hisperc	.979	1.021
	asnperc	.974	1.027

Model 4		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	blackperc	.909	1.100
	hisperc	.898	1.113
	asnperc	.844	1.185
	colperc	.224	4.470
	properc	.260	3.848
	meanhv1000	.345	2.899
	mfinc1000	.279	3.588

CFPPs sited 1995 – 2004 (2000 Census)

Model 1		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	minperc	1.000	1.000

Model 2		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	minperc	.782	1.278
	colperc	.171	5.838
	properc	.183	5.464
	meanhv1000	.590	1.694
	mfinc1000	.855	1.170

Model 3		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	blackperc	.973	1.028
	hisperc	.970	1.031
	asnperc	.966	1.036

Model 4		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	blackperc	.760	1.316
	hisperc	.842	1.188
	asnperc	.850	1.177
	colperc	.169	5.904
	properc	.183	5.479
	meanhv1000	.563	1.778
	mfinc1000	.830	1.205

CFPPs sited 2004 – 2012 (2010 Census)

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	minperc	1.000	1.000

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	minperc	.806	1.241
	colperc	.196	5.108
	properc	.234	4.280
	meanhv1000	.466	2.147
	mfinc1000	.445	2.245

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	blackperc	.983	1.018
	hisperc	.989	1.011
	asnperc	.984	1.016

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	blackperc	.898	1.113
	hisperc	.779	1.283
	asnperc	.791	1.265
	colperc	.193	5.172
	properc	.229	4.367
	meanhv1000	.409	2.442
	mfinc1000	.440	2.272