HOPES AND OPPORTUNITIES FOR INNER CITY RESIDENTS:
Temporal and Spatial Assessment of Racial and Socioeconomic Conditions of Neighborhoods Adjacent to Brownfields in the Detroit Metropolitan Area

BY

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ABSTRACT

Although many environmental justice studies have examined racial and socioeconomic disparities in locations of hazardous waste facilities, no study has examined to date racial and socioeconomic disparities in brownfield locations. In order to fill this gap, this dissertation thus examines the racial and socioeconomic characteristics of neighborhoods adjacent to brownfields in the Detroit region from 1960 to 2000. Based on some of the past sociological claims in the specific context of brownfields, this dissertation argues that deindustrialization in the 1960s and the subsequent concentration of poverty in the 1970s were responsible for socioeconomic disparities in brownfield locations. That is, socioeconomic conditions of brownfield neighborhoods are worse than socioeconomic conditions of non-brownfield neighborhoods. Moreover, this dissertation also argues that residential segregation imposed on minorities also was responsible for racial disparities in brownfield locations, meaning that brownfield neighborhoods are minority concentrated compared to non-brownfield neighborhoods.

This dissertation combines the locations of brownfields provided by the Michigan Department of Environmental Quality with 1960, 1970, 1980, 1990, and 2000 US Census data employing distance-based methods. Results reveal that brownfield neighborhoods show a higher concentration of minorities and a lower socioeconomic condition than non-brownfield neighborhoods. In addition, race is the strongest independent predictor of brownfield locations. Longitudinal analyses of brownfield locations from 1960 to 2000

reveal that brownfield neighborhoods experienced greater socioeconomic decline than did non-brownfield neighborhoods. When socioeconomic characteristics in 1970 are controlled, distinctive patterns of subsequent changes in socioeconomic characteristics were found on the basis of initial socioeconomic status. For the wealthiest neighborhoods in 1970, brownfield neighborhoods experienced greater socioeconomic declines than non-brownfield neighborhoods in the 1970s. No significant changes in socioeconomic differences between brownfield and non-brownfield neighborhoods were found in later decades. For second and third wealthiest neighborhoods, brownfield neighborhoods experienced greater socioeconomic declines than non-brownfield neighborhoods in both the 1970s and 1980s. For the most impoverished neighborhoods, no significant changes in socioeconomic differences between brownfield and non-brownfield neighborhoods were found in any decade. Finally, impoverished and minority-concentrated neighborhoods tend to get priority in brownfield cleanup. In summation, findings from this dissertation suggest that deindustrialization led not only to economic and social inequality but also to environmental inequality.

CHAPTER 1: INTRODUCTION

This dissertation assesses racial and socioeconomic conditions of neighborhoods near brownfields in the Detroit metropolitan area. Brownfield development aims at remediation and subsequent redevelopment of such contaminated properties (Fitzgerald and Leigh 2002; Hula 2001; 2002; Simons and Winson 2002). Brownfield development is often expected to improve environmental as well as economic conditions for residents living adjacent to brownfields, but regardless of such optimism, relatively few studies have examined to date the socioeconomic consequences of brownfields, especially those on neighborhoods adjacent to those properties. That is, current brownfield studies have tended to focus on racial and socioeconomic differences between cities and municipalities with and without the presence of brownfields (Greenberg et al. 2000). The above study does not necessarily, however, reveal that brownfields are disproportionately located near impoverished and minority neighborhoods because the unit of analysis of the above study is city. Therefore, this dissertation is to first assess racial and socioeconomic characteristics of neighborhoods adjacent to brownfields. In addition to assessment of the racial and socioeconomic conditions of individuals residing near brownfields for the first time, there are no theoretical explanations of why impoverished and minority populations might be residing near brownfields. Those two are objectives of this dissertation. The study area is a tri-county area (Macomb, Oakland, and Wayne) that was the 1990 definition of the Detroit Primary Statistical Area provided by the US Bureau of Census. The Detroit metropolitan area was selected because this area is the largest urbanized areas in the state of Michigan where the majority of brownfields tend to be concentrated. This chapter will discuss research questions of this study, a brief overview of brownfield development especially in the state of Michigan, and organization of this dissertation.

1-1 Research Questions

In order to fill theoretical and empirical gaps, this dissertation will address three questions. They are: (1) Whether brownfields are located disproportionately in

minority and low-income neighborhoods; and (2) Whether the presence of brownfields is associated with socioeconomic declines in nearby neighborhoods over time; and (3) Whether brownfield cleanup prioritization is associated with racial and socioeconomic conditions of nearby neighborhoods.

This dissertation has two purposes: make academic contributions and explore policy implications. In terms of academic contributions, in order to answer the first two questions, this dissertation will develop a theoretical framework which explains why brownfields are expected to be located near impoverished and minority neighborhoods. Although environmental justice research has already developed theoretical explanations of disparate siting of hazardous waste facilities, such explanations limitedly explain disparate brownfield locations (see chapter 4 for more detailed discussion). For instant, Saha and Mohai (2005) explain that hazardous waste facilities tend to be sited near impoverished and minority neighborhoods due to economic reasons for facility owners; because lands near such neighborhoods are inexpensive in these areas, it is profitable for the owners to site their facilities there. Governments tend to issue a permit for hazardous waste facilities in hope for economic benefits such as employment opportunities from such siting. In terms of brownfields, because the key issue is why properties are abandoned rather than sited, permits from governments are irreverent to explain why brownfields are located in impoverished and minority neighborhoods. This is because no permit from governments is required for facilities to be relocated. In terms of economic rationale of owners, because owners of facilities did not directly introduce environmental burdens on nearby neighborhoods by relocating their facilities, it is difficult to attribute this rationale causes disproportionate environmental burdens on adjacent neighborhoods. Rather, disproportionate environmental burdens from brownfields are appeared to result from the departure of facilities and failure to appropriate subsequent management of these facilities. Because of the above differences between hazardous waste facilities and brownfields, new theoretic explanations of locational disparity of brownfields are needed. Although a few studies (Greenberg et al. 2000; Kuehn 2000; Mank 2000; Solitare and Greenberg 2002) approach brownfields within the environmental justice framework, no study, to my best knowledge, develops theoretical frameworks to explain why disparate brownfield locations are

expected at least in the field of environmental justice.

In order to fill this gap, my dissertation connects an existing theory, or concentration of poverty, to brownfields – concomitant of deindustrialization –, claiming that locations of brownfields are associated with socioeconomic decline of adjacent neighborhoods to brownfields. That is, deindustrialization leads to concentration of poverty in central cities where manufacturing facilities were previously located. Departure of such facilities deprived of employment opportunities for nearby residents who did not possess high skill and education level, resulting in pervasive joblessness in those areas. Subsequently, concentration of poverty resulted in creation of additional brownfields that are service businesses for local residents. Although concentration of poverty exists in urban sociology literature, this dissertation intends to connect that deindustrialization also resulted not only in social and economic inequalities but also in environmental inequality.

In addition to developing theoretical framework, there is no study, to my best knowledge, examining who are living near brownfields. The neighborhood-level of assessment is crucial because many contemporary environmental justice studies (Ash and Fetter 2004; Boer et al. 1997; Boone 2002; Mohai and Bryant 1992; Pastor et al. 2001, 2004, 2005; Pulido et al. 1996; Stretesky and Hogan 1998) tend to focus on disproportional environmental burdens in the neighborhood level (e.g., census tracts or block groups) rather than such burdens in larger geographic levels (e.g., cities or counties). Because the presence of brownfield could be regarded as another type of environmental burdens, the neighborhood level assessment is important to link to previous environmental justice studies to answer whether brownfields add other environmental burdens to those who are already exposed to disproportional environmental burdens. Therefore, empirical assessment proposed in this dissertation will address whether impoverished and minority populations might be exposed to an additional environmental burden, namely the presence of brownfields.

In terms of policy implications, this dissertation can provide a critical first step to help policy makers become aware of efficient and effective brownfield policies given possible shortcomings of brownfield development (see the background section for detailed discussion). The conventional economic development policy proves to be ineffective (Blakely and Bradshaw 2002; Jennings 2004; Spencer and Ong 2004; Stoecker 1997).

That is, the mere hosting of outside businesses in impoverished and minority neighborhoods, as the conventional approach of economic development, may not always work due to the low level of skills that local residents possess in conjunction with racial discrimination in the labor market (Ihlanfeldt 1999; Kasinitz and Rosenberg 1996; Meiklejohn 1999; Neckerman and Kirschenman 1991; Pager 2003; Turner 1997). One alternative could be encouragement of public participation in the brownfield development process to identify local needs (see the background section for detailed discussion). Thus, knowledge of target populations can lead to client-specific economic development policies reflecting needs of local residents. Further, assessments of the socioeconomic changes to neighborhoods on the basis of levels of concentration of brownfields can provide policy makers with information about where economic development is most needed. Finally, if brownfields, as another type of environmental burdens, are located near other hazardous waste facilities, lowering of the cleanup standards which brownfield development often offers to developers perhaps should be reconsidered.

1-2 Overview of Brownfield Development

The United States Environmental Protection Agency (USEPA) Region 5 defines brownfields as "abandoned, idled, or underutilized industrial or commercial sites where expansion or redevelopment is complicated by real or perceived environmental contamination that can add cost, time, or uncertainty to a redevelopment project" (Davis 2002: 5). In addition, the United States Office of Technology Assessment (USOTA) also defined brownfields as sites "whose redevelopment may be hindered not only by potential contamination, but also by poor locations, old, or obsolete infrastructure, or other less tangible factors often linked to neighborhood decline" (Davis 2002: 5). Although definitions of brownfield between USEPA region 5 and USOTA share similarities, the definition from USOTA adopts a more liberal definition of brownfield by including properties that do not suffer from environmental contamination. In terms of the definition that USOTA provides, it is unclear what roles environmental contamination plays in determining brownfields. Under the USOTA definition, a run-down public housing complex with little suspicion of environmental contamination can be a brownfield. Although USEPA region 5 provides a more stringent definition of brownfields by adding environmental contamination factor and commercial and industrial

sites, this definition is also ambiguous. Specifically, because the definition of USEPA region 5 includes perceived environmental contamination, it is subjective to decide which properties are brownfields and which properties are not. Therefore, a more objective definition of brownfields is needed to eliminate confusions in designating brownfields.

In addition to ambiguous nature of brownfield definition, there is considerable confusion between voluntary cleanup programs and brownfield development. Voluntary cleanup programs tend to state-sponsored programs to encourage owners and developers to clean up contaminated properties. However, unlike brownfield development, voluntary cleanup programs do not focus on redevelopment of such properties; rather, their main goal is to eliminate environmental contamination (Reisch and Bearden 2003). Environmental Law Institute states that "… voluntary [cleanup] programs do not focus on redevelopment nor do they target urban site specifically. Voluntary [cleanup] programs are more often aimed at simple, less contaminated sites cleaned up regardless of whether they are reused. Brownfield programs, on the other hand, are more likely to focus on redevelopment and be part of a broader State strategy or set of social policies aimed at improving distressed urban areas" (Reisch and Bearden 2003: 4).

Although there are an estimated 21,000 brownfields in the U.S. (Fitzgerald and Leigh 2002), the exact numbers are extremely difficult if not impossible to ascertain for several reasons. Because of ambiguous brownfield definition discussed above, each state adopts slightly different definitions of what constitutes a brownfield (Mank 2000; Reisch and Bearden 2003). In other words, a brownfield in one state would not necessarily be a brownfield in another. For example, it appears that the state of Michigan adopts USOTA definition of brownfield[1] (Trigger 2002) whereas the state of Illinois tends to designate contamination as the most important component of brownfields (Montgomery 2002). Cleanup standards tend to be different from states. For instance, the state of Mississippi rely on risk assessment rather than the cleanup standard while the state of Florida provides specific cleanup standard for each site on the basis of risk (Reisch and Bearden 2003). Further, because brownfields are associated with stigma, local

[1] There is no formal definition of brownfields in the Michigan's Brownfield Redevelopment Financing Act (Michigan Legislature undated). However, based on the definition of 'Blighted Properties' in this Act, it is assumed that brownfields in the state of Michigan include abandoned, idled, or underutilized industrial or commercial sites without tangible environmental contamination.

governments are often reluctant to declare them as such (Greenberg et al. 2000). Finally and most importantly, mothballed properties in which there is neither physical activities nor delinquent property taxes make it difficult to assess the exact number of brownfields. Although such mothballed properties are clearly underutilized or even abandoned, property owners pay their property taxes; thus, there is no legal basis for governments to investigate whether or not those properties are contaminated. Because it is expensive to clean up environmentally contaminated properties once environmental contamination is known, it is a better deal for property owners to pay property taxes but not place their properties on the real estate market (Greenberg et al. 2000). For these reasons, exact assessment of brownfields is a difficult if not impossible plus costly task.

Brownfield development was the hot issue at the 1993 U.S. Conference of Mayors (Fitzgerald and Leigh 2002; Simons and Winson 2002), and at the 1998 conference, mayors declared that brownfield development should be the highest priority for federal government support (Greenberg 2002, 2003). In 1994, the EPA initiated a grant program (Brownfield Assessment Pilot Grant) to assist municipalities in assessing environmental contamination in potential brownfield sites in their jurisdictions (Solitare and Greenberg 2002). The U.S. Department of Housing and Urban Development (HUD) also published a study exploring the potential federal roles in state-level brownfield development (HUD 1999). In order to remove the barriers to redevelopment of abandoned contaminated properties, the EPA removed more than 30,000 sites from the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database[2] as part of its brownfields initiative (Solitare and Greenberg 2002). Although some have argued that brownfields tend to be less severely contaminated than sites listed on the Superfund national priority list (Mank 2000; Reisch and Bearden 2003; Davis 2002), there is no published study that to date compares the severity of contamination between brownfields and the Superfund National Priority List (NPL).

In Response to the growing attention paid to brownfield development, the U.S.

[2] This database, provided by the EPA, contains information on actual as well as potentially hazardous waste sites (i.e., Superfund national priority list sites) and remedial actions of such sites. Specifically, citizens can report sites suspected to be environmentally contaminated; then, those sites are registered in the CERCLIS database. The EPA presumably evaluates sites listed in this database, and then determines whether such sites are designated as NPL sites.

Senate and House of Representatives passed the Brownfield Revitalization and Environmental Restoration Act (BRERA) in December of 2001. This act modifies the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) "to encourage brownfield development by providing federal liability relief to prospective purchasers of brownfield properties and to persons who undertake cleanups of these properties under state law, and by providing funding both to state brownfield programs and to local government who seeks to return brownfield properties to productive use" (Hird 2002: xxxv). Because rigid liability scheme under the CERCLA often discourage development of brownfields[3], the BRERA can encourage redevelopment of those sites by provision of federal liability relief. Further, the BRERA states that the federal government needs to create the funding sources to help state and local governments to develop strategies for brownfield development including voluntary cleanup programs (Hird 2002).

Paralleled with the federal government, the state of Michigan has initiated a series of efforts to encourage brownfield development. First, the Brownfield Redevelopment Financing Act, passed in the late 1990s, authorizes local governments to develop comprehensive methods of financing brownfield development, methods that include: (1) creation of a brownfield development authority, (2) authorization of implement tax increment financing, (3) designation of brownfield redevelopment zones, and (4) authorization of the acquisition and disposal of specific properties (Michigan Legislature undated; Trigger 2002). Furthermore, the Detroit Economic Growth Corporation (DEGC), established in 1978 as a public-private partnership to assist businesses in providing jobs as well as in leveraging private investment in Detroit, has been interested in brownfield development (DEGC undated). DEGC staff members of the Detroit Brownfield Redevelopment Authority actively pursue brownfield development by identifying and consulting with investors interested in investing in cheap Detroit properties.

[3] One of the biggest barriers under the Resource Conservation and Recovery Act (RCRA) in 1976 and CERCLA in 1980 lies in ambiguous cleanup standards. Wagner (2002: 17) states that "Prospective Purchasers who desire quantification of cleanup costs before purchasing a contaminated site are dismayed to learn that government entities are often unable to provide assistance in determining what constitutes an acceptable cleanup, even though ultimate redevelopment of a contaminated property may serve the public interest."

The state of Michigan additionally developed the Clean Michigan Initiative (CMI) of which voters approved in July 1998. The bill, whose purpose is to preserve and protect Michigan's valuable environmental assets, then, proceeded to issue $675 million in general obligation bonds for environmental cleanup and natural resource protection. The administration of Governor John Engler conceived of this initiative, which for the issuance of general obligation bonds required the approval of two-thirds of the legislature and a majority of the voters. Because this was a well-intentioned proposal, there appeared to be little organized protest. However, the 1998 Democratic gubernatorial candidate Geoffrey Fieger complained that the proposal "would not toughen environmental enforcement" whereas it enjoyed the supports of various public and private groups such as the Michigan Municipal League, Urban Core Mayor, Michigan Township Association, Southeast Michigan Council of Government, and Michigan Chamber of Commerce (Katz 2002: 7). There is little evidence to indicate that Michigan environmental groups got involved in this initiative either for or against.

Although the CMI is not restricted to brownfield development, this section discusses brownfield development under that legislation. Apparently, more than half of the initiative's budget ($335 million) was allocated to brownfield redevelopment with the bulk of the brownfield fund ($263 million out of $335 million) earmarked for the cleanup of contaminated properties (Katz 2002; Hula 2002). Under the CMI, local governments were to nominate contaminated government-owned properties[4] in their jurisdictions, after which the State selected "winners" on the basis of development potential and contamination level (Hula 2002). Governments often acquire contaminated properties when property owners abandon them and default on their property taxes (Meyer and Lyons 2000).

1-3 Promises of Brownfield Development

Three broad promises are associated with brownfield development: (1) economic development of distressed areas in socioeconomically declining U.S. central cities, (2) prevention of suburban sprawl, and (3) efficient usage of governmental resources. Some scholars (Fitzgerald and Leigh 2002; Hula 2001; 2002; NEJAC 1996; Simons and

[4] Most brownfield properties under CMI are owned by local governments (county or municipalities). However, some brownfields are owned by private parties as well.

Winson 2002) claim that brownfield development has emerged as an alternative method for addressing the problem posed by hazardous waste sites in the United States. In other words, the Superfund remediation of contaminated properties does not take into account economic redevelopment. Furthermore, developers, financial institutions, and lenders all tend to avoid investing in properties listed in EPA's CERCLIS database (Solitare and Greenberg 2002). Because of the above, contaminated properties often prove difficult to redevelop in distressed U.S. central cities. By removing the stigma (listed in CERCLIS) and providing incentives (e.g., financial subsidies, flexible standards, and/or liability relief), such properties can arguably be redeveloped and thus become of benefit to local residents who suffer from impoverished socioeconomic conditions.

Some scholars (Bealey and Manning 1997, Greenberg et al. 2001; McAvoy 2004; Roseland 1998) also claim that brownfield development can reduce suburban sprawl. Beatley and Manning (1997) find that land consumption has outpaced population growth in U.S. metropolitan areas. When governments encourage infill development, they might cause the amount of suburban development to fall. Some states (e.g., Maryland and New Jersey) identify brownfield development as a smart growth option (Greenberg et al. 2001), and Greenberg et al. (2001) argue that brownfield development is the most viable option in smart growth and growth management policies. Protection of the ecosystem can be realized through reducing suburban development (Zovanyi 1998). That is, by suppressing development in suburban areas, such land can be devoted to various ecological purposes such as habitat conservation (Noss et al. 1997), wetland and coastal preservation (Beatley et al. 1994), and farm land preservation (Stokes et al. 1997).

Finally, brownfield development can lead to efficient use of limited governmental resources, this efficiency being realizable because brownfield properties already contain existing infrastructures (Fitzgerald and Leigh 2002; Simons and Winson 2002) even though they can sometimes serve as obstacles to development when developers prove unable to find parcels large enough for their purposes (Fischer 1997). By the same token, tax revenues experience an increase due to brownfield development, and an increased tax base for impoverished central cities is crucial for provision of better municipal services for clients. According to the 2000 U.S. Mayoral report, for example, there are more than 21,000 brownfield properties encompassing 81,000 acres in 231 cities

which if completely developed would realize an estimated gain in tax revenues of $878 million (Fitzgerald and Leigh 2002; 74).

In short, brownfield development can be an excellent example of sustainable development. The popular paradigm of sustainable development developed by Campbell (1996) is to balance economic development, environmental protection, and promotion of equity (Beatley 1995; Beatley and Manning 1997; Roseland 1998). As discussed, brownfield development can protect environment by reduction of suburban sprawl. Brownfield development can also secure economic development by investment of abandoned properties. Finally, brownfield development can also promote equitable resource distributions within a metropolitan area by developing properties in neighborhoods in U.S. central cities where socioeconomic declines have been evident after the 1970s (Wilson 1987; 1996). However, in order to realize equitable resource distributions, benefits from brownfield development should be given to local residents who have been suffering from concentration of poverty. Unfortunately, there is scientific evidence benefits from such development tend to be given to local residents, and this is one of the critical environmental justice issues (see chapter 3 for more detailed discussions).

1-4 Study Design and Organization

The study area of this dissertation is the tri-county region in the Detroit metropolitan area[5]. Further, this dissertation will rely on the secondary data, specifically the decennial Census of Housing and Population from 1960 to 2000. This dissertation will employ spatial and temporal analyses. Spatial analysis will be conducted by application of the Geographic Information System (GIS). That is, brownfield locations will be mapped on the digitized map with census units (i.e., census block groups or census tracts), which allows researchers to analyze the racial and socioeconomic conditions of neighborhoods geographically close to brownfields. Temporal analysis will be conducted on the basis of racial and socioeconomic characteristics of neighborhoods over time. In other words, this temporal analysis can address the question of whether neighborhoods adjacent to brownfields experienced the dramatic decline in

[5] In the 1990 definition, the tri-county area, or Macomb, Oakland, and Wayne counties (includes the city of Detroit) was the Primary Metropolitan Statistical Area (PMSA). However, the Detroit PMSA is expanded in 2000 by adding three additional counties, Lapeer, Monroe, and St. Clair counties (see Figure 5-1).

socioeconomic conditions from 1960 to 2000.

The order of dissertation is as follows. This chapter discussed the research questions and general overview of brownfield development. Chapter 2 will review literature on environmental justice with an emphasis on empirical studies with respect to locational disparity of hazardous waste facilities. Chapter 3 will also review literature on brownfield development. The purpose of reviewing literature on brownfield development is not only to link between environmental justice and brownfield development but also to introduce what types of research have been conducted on brownfield development. Chapter 4 will provide theoretical framework for this dissertation, borrowing from urban sociology literature, and such a framework should differ from the one in environmental justice explaining locational disparity of hazardous waste facilities. Chapter 5 will discuss method of this dissertation. Chapters 6 through 9 will present results of research questions posed on this dissertation. Specifically, Chapter 6 will present results to answer whether brownfields are found near impoverished and minority neighborhoods. Chapter 7 and 8 will present results to answer whether the presence of brownfield is associated with decline in socioeconomic conditions of adjacent neighborhoods from 1960 to 2000. Chapter 9 will present results to answer whether racial and socioeconomic conditions of neighborhoods can predict cleanup prioritization of brownfields. Finally, Chapter 10 will conclude this dissertation by summarizing major findings and providing future research agendas.

CHAPTER 2: LITERATURE REVIEW ON ENVIRONMENTAL JUSTICE

This chapter reviews existing quantitative studies pertaining to environmental justice, specifically, studies that examine locational environmental disparity[1]. The purpose of reviewing such literature is to determine the types of research that have previously been conducted and to identify the major findings of those studies. In addition, the methodological techniques employed, especially as regards spatial analysis, come from previous environmental justice studies because there is no previous study on racial and socioeconomic disparities on brownfield locations at the neighborhood level. It is important to note that all environmental justice studies are not reviewed in this chapter, but studies reviewed in this chapter are a fair representative of studies examining locational environmental disparity.

Many qualitative environmental justice studies employ the case study method to examine the evolution of environmental struggles in a community, the outcomes of such protests, the types of actors involved, and the strategies they implement to achieve the goals of their protests. Such studies help researchers comprehend causal factors and subsequently to formulate hypotheses and theories (Mohai and Saha 2007). In other words, many hypotheses from quantitative studies indeed come from prior qualitative studies. Thus, it is important to appreciate the importance of qualitative studies in the field of environmental justice. For example, Cole and Foster (2001) introduce a case in Chester, Pennsylvania, where governments granted placement of commercial waste facilities in the African American enclave. In order to prevent from siting of such

[1] There are several lines of locational environmental disparity inquiry. Many studies use hazardous waste facilities as proxy for environmental burdens. Such studies map locations of such facilities and then compare the socioeconomic conditions of neighborhoods adjacent to such facilities and neighborhoods at a distance from them. Other studies probe into the relationship between levels of air pollution in census units (e.g., zip codes, census tracts, block groups) as well as racial and socioeconomic characteristics of the units. Although those studies that consider only one source of pollution exclude numerous other sources of pollution (e.g., land and water pollution), the actual level of pollution is a better proxy than are locations of hazardous waste facilities. The final type of locational environmental disparity resides in transportation-related environmental inequalities, with studies of the same examining the relationship between transportation-related environmental disamenity (e.g., road density, volume of vehicle trips, level of vehicle emissions) of census units and socioeconomic characteristics of those units.

facility, coalitions between Chester Residents Concerned about Quality of Life (CRCQL) and external organizations such as Campus Coalition Concerning Chester (C4) was formed. Known as C4, such a coalition delivered the strong message to local governments and corporations, and settlements between companies and residents were finally reached. Indeed, the legal solution which residents pursued previously failed, but building a coalition was proven to be effective (Cole and Foster 2001). Furthermore, Pulido et al. (1996) conduct a historical analysis of environmental inequalities in two Los Angeles neighborhoods and conclude environmental inequalities result from various historical factors such as housing discrimination, development of zoning ordinance, and labor market division by races. From this study, several subsequent studies included industrial land use as an independent variable to explain locational disparity (Lejano and Iseki 2001; Pastor et al. 2004).

On the other hand, some scholars attempt to link the environmental justice movement into broader social movement theories. Taylor (2000), for instance, examines what factors led to the emergence of the environmental justice movement in 1980s and 1990s. The author argues that the environmental justice movement employs an injustice frame as the master frame which identifies not only human harming nature but also race, gender, and class discrimination in various environmental contexts. She further claims that the environmental justice movement tends to take advantage of existing social networks (civil rights activists and social justice activists) to expand their membership. The academic community also contributed to the environmental justice movement by advancing spatial analysis skills. Finally, she states that "[l]ike mainstream environmental activists, environmental justice activists were poised to take advantage of the political opening the pro-environmental Clinton-Gore administration presented" (Taylor 2000: 565). In short, although the importance of qualitative environmental justice studies should not be overlooked, reviewing such studies is beyond the scope of this dissertation.

2-1 Early Studies on Locational Disparity

The general characteristic of early spatial environmental justice studies lies in the use of the unit-hazard coincidence method (to be discussed later in the section). The United Church of Christ (UCC) study (1987) compares racial and socioeconomic characteristics

of zip codes areas hosted at least one hazardous waste treatment, storage, and disposal facilities (TSDF) with the characteristics of zip codes not hosted any TSDF. This study finds that race is an independent predictor of locations of hazardous waste treatment, storage, and disposal facilities (TSDFs). Later, Mohai and Bryant (1992), using the 1990 Detroit Area Study, a probability sample of three Michigan counties (Macomb, Oakland, and Wayne county), subsequently find race to be a stronger predictor (and independent predictor as well) than income in measuring distance between residences of survey participants and distance from 14 commercial hazardous waste and 2 planned facilities. Unlike earlier findings indicating the locational disparity of TSDFs, Anderton et al. (1994) discovered that race is not a statistically significant predictor of such facilities. Referring to the UCC study (1987), Anderton et al. (1994) claim to replicate the UCC study by employing a different unit of analysis (UCC use zip code areas and Anderton et al. use census tracts). They argue that their unit of analysis is superior to the UCC's because census tracts are less likely than zip code areas to lead to ecological fallacy[2].

Anderton et al. (1994) find that the percent of African Americans and Hispanics are not significant predictors but the percent of persons employed in manufacturing occupations is a significant predictor of whether census tracts host at least one TSDF facility. Based on this finding, the authors claim that census tracts hosting TSDFs are generally white working class neighborhoods. In a later study, Anderton et al. (1997) examine the relationship between sites under Comprehensive Environmental Response Compensation and Liability Act (CERCLIS) and National Priority List (NPL)[3] sites and demographic characteristics based on 1990 US Census data using census tract as the unit of analysis. They find that the differences in percent of African Americans and

[2] The term ecological fallacy refers to the failure to acknowledge errors in aggregate data. That is, interpretation of individual characteristics identified in aggregated data sets often gives rise to inaccurate descriptions of reality. Anderton et al. (1994: 232) claim "Because geographic data can be aggregated to produce information on larger regions, it seems reasonable to begin with an analysis of areas that are as small as is practical and meaningful. Beginning with too large a geographic unit invites the possibility of 'aggregation errors' and 'ecological fallacies'; that is, reaching conclusions from a larger unit of analysis that do not hold true in analyses of smaller, more refined units."

[3] Sites are listed in CERCLIS if they are under suspicion of environmental contamination. Because sites in CERCLIS can be listed through simple phone calls from concerned citizens, not all CERCLIS sites are environmentally contaminated. Through site assessments, sites listed in CERCLIS will be listed in the NPL if contamination scores of sites are higher than the predetermined threshold by the US EPA. When sites are listed in the NPL, they are thoroughly cleaned up.

Hispanics between census tracts containing at least one CERCLIS and census tracts not containing CERCLIS are insignificant. Examination of NPL sites yields the same conclusion. However, the authors do in fact find that the likelihood of prioritization of cleanups may be influenced in an ultimately inequitable fashion; that is, communities with a high percent of African American and impoverished population are less likely to be designated NPL sites. The authors claim that such disparity cannot be strong evidence of environmental inequality because severity of contamination is not considered. That is, it is possible that NPL sites near African American neighborhoods are not as seriously contaminated as ones in white neighborhoods. Therefore, it is important to consider "Hazards Ranking System for NPL designation" to reach a more definitive conclusion that racial disparity of NPL designation exists (Anderton et al. 1997: 23). Finally, Davidson and Anderton (2000), relying on 1990 US tract-level Census data, find that census tracts hosting at least one the Resource Conservation and Recovery Act (RCRA) facility[4] exhibit lower percentage of African Americans and Hispanics and a higher percent of persons employed in manufacturing industries than census tracts not hosting RCRA facility on the national as well as metropolitan levels (employment status being important here). Nonetheless, when they include census tracts adjacent to at least one facility[5], the percent of African Americans becomes higher than census tracts not hosting them.

The emergence of counterevidence with respect to environmental inequalities requires more conclusive findings supporting disproportionate environmental burdens imposed on impoverished and minority population. Krieg (1995) examines the relationship between waste sites and demographic characteristics by considering the spatial dynamics of industrial activities in Greater Boston, that the differing histories of industrial development within region should be considered as determinant factors in revealing the relationship between waste sites and demographic characteristics of towns[6]. He finds further that race is a strong predictor for location of waste sites in areas with a

[4] Facilities are listed in the RCRA database if they handle toxic chemicals defined under the Resource Conservation and Recovery Act.
[5] They use centroid-containment method with 3 mile radius from each RARC facility.
[6] The author categorizes townships (N=44) into two groups. Townships inside or close to route 128 (N=25) represent a newly developed industrial region while the remaining townships (N=19) represent a historical industrial region.

long history of industrial activity (i.e., Boston) while class is a strong predictor of the sites in areas with a relatively brief history of industrial activity (suburban townships in Greater Boston). Although this study highlights the fact that a history of industrial activity of an area turns out to be a critical factor to explain relationships between racial and socioeconomic characteristics and locations of waste sites, he reaches his conclusion based on bi-variate analysis.

Lejano and Iseki (2001) examine the relationship between a number of TSDFs and racial composition (the 1990 US Census with zip code as unit of analysis) by controlling for socioeconomic characteristics and the total area of the zip code area devoted for industrial land use. In other words, the dependent variable of this study is the number of TSDFs in a zip code area in Los Angeles County regardless of the exact locations of such facilities. By employing parsimonious regression analysis excluding statistically insignificant variables, they find that the proportion of non-Black Latinos, proportion of impoverished (fraction of the population with incomes under 50% of the poverty line), and the total area industrial land use are statistically significant predictors of the number of TSDFs, while income is not a significant predictor of number of TSDFs. Two-stage ordinary least square regression[7] indicates that the proportion of non-black Latinos remains statistically significant whereas as proportion of impoverished populaces and estimated industrial areas become statistically insignificant. The authors interpret the significance of the proportion of Latino and total industrial area as evidence of zoning and land use policies contributing to unequal distribution of such facilities.

Ringquist (1997) argues that previous environmental justice studies here have overlooked several important points, as follows: (1) Sites in the Toxic Release Inventory (TRI) are more inclusive than are ones in RCRA (most used in studies); (2) no multiple impact is considered; (3) the amount of release is not considered; (4) case studies have weak external validity; and (5) appropriate comparison groups need to be chosen (national average v. state average). Relying on 1990 US Census data with zip code as unit of analysis, the author employs multivariate analysis of four sets of

[7] The authors use two-stage OSL to avoid the endogenous bias in which two variables cause each other. Because locations of TSDFs influence as well as are influenced by industrial land uses, the total industrial area is estimated by the proportion of Latino residents in 1980 and 1990 and income in 1980 and 1990. The estimated industrial area is replaces the total industrial area in the earlier simple regression model.

dependent variables: (1) the existence of zip code hosting in at least one TRI facility, (2) the number of TRI facilities in zip code areas, (3) the density of TRI facilities, and (4) the amount of toxic release and finds that racial and socioeconomic variables are significant predictors of all four. In terms of significance, the author calculates expected values with increase of one standard deviation in a variable and find that the general background characteristics of residential areas which are (1) the percent residents in urban areas, (2) percent of persons employed in manufacturing occupations, (3) percent of homeowners, and (4) median house age best account for the distribution of environmental risks arising from TRI facilities followed by race and class.

Other studies find the existence of environmental inequality in Superfund sites (Hamilton and Viscusi 1999[8]; Stretesky and Hogan 1998; Zimmerman 1993) in distinction to the findings of Anderton et al. (1997). Stretesky and Hogan (1998), for instance, examine the relationship between Superfund sites[9] and the racial, ethnic, and economic characteristics of surrounding areas in the state of Florida. Mutivariate analysis indicates that race remains a significant predictor of such sites when controlling for economic variables. Longitudinal analyses reveal that the percent of minority populations has increased in census tracts with at least one Superfund site. Based on these findings, the authors conclude that "environmental justice is more than just the direct placement of hazards into minority communities. Even without evidence for direct discrimination, clearly, social processes beyond the sitting decisions themselves are furthering such inequality" (Stretesky and Hogan 1998: 284).

2-2 Application of a New Method and a New Dataset

The above studies employ the unit-hazard coincidence method, the term introduced by Mohai and Saha (2006) referring to simple dichotomization of spatial units in accordance with the hosting or non-hosting of at least one hazardous waste facility. This method does not accurately capture all geographic units such as census tracts or census block groups which might be affected by such facilities. Specifically, a problem of the unit-hazard coincidence method lies in an assumption that effects of hazardous waste facility are solely in host geographical units such as census tracts or zip code areas

[8] Unlike other studies, Hamilton and Viscusi (1999) employ the distance-based method.
[9] Superfund sites refer to sites listed in the NPL.

(Downey 2006; Saha and Mohai 2006, 2007). In order to capture areas that might affected by hazardous waste facilities, a new method, the distance-based method, has been developed. By employing the Geographic Information System (GIS), the distance-based method creates circular buffer around each facility and aggregate or average demographic characteristics of geographical units within the circular buffers. Thus, this method allows researchers to more precisely estimate neighborhoods near polluting facilities (Mohai and Saha 2006). Results differ from the unit-hazard coincidence method when the distance-based method is employed. For example, Boer et al. (1997) compare results employing the unit-hazard coincidence method to ones employing the distance-based method and find that the percent of African Americans in census tracts within one mile radius of TSDFs in Los Angeles County is significantly higher than it is for census tracts beyond a one-mile radius of TSDFs. Relying on the unit-hazard coincidence method, there is no significant difference in percent of African Americans between census tracts hosting or not hosting at least one TSDF.

Although Boer et al. (1997) are the first to show that different results are yielded on the basis of methods (the unit-hazard coincidence method v. the distance-based method), the study area of this study is one California county. Thus, it is difficult to assert that this pattern maintains at the national level. On the other hand, Mohai and Saha (2006, 2007) compare results employing the unit-hazard coincidence method to ones employing the distance-based method at the national level. They find that race is not a significant predictor of locations of TSDFs when the unit-hazard coincidence method is used while it becomes a significant predictor of locations of TSDFs when the distance-based method is employed. Furthermore, race is an independent predictor of locations of TSDFs when employing the distance-based method. When distance from TSDFs lengthens from one mile to three mile, race becomes a stronger predictor yet income loses its explanatory power[10].

As another example of a study employing the distance-based method, Pastor et al. (2004) examine the locations of TRI facilities and demographic characteristics of nearby

[10] Strength of explanatory power refers to values of a coefficient. For example, a coefficient of the percent of African American is 0.698 with one mile radius from TSDFs, the coefficient increases to 1.522 with three mile radius from TSDFs. A coefficient of mean household income is -0.025 with one mile radius from TSDFs, the coefficient decreases to -0.015 with three mile radius from TSDFs (Mohia and Saha 2006: 395 Table 3).

neighborhoods in the state of California by using the 2000 US Census data (census tract as unit of analysis) and the TRI in 2000. Results show that when controlling variables (home ownership, income, population density, and occupation), race is a significant predictor of locations of such facilities, regardless of use of a minority as one unit (i.e., non-white) or use of different racial groups (i.e., African American and Hispanic). That is, higher minority presence in a census tract increases the probability of its hosting facilities. The authors adjust spatial autocorrelation[11] by employing two-stage regression analysis, producing results which show that, even after adjusting for spatial autocorrelation, race remains a significant predictor in spite of any decline in coefficient or t-statistic. They state that "The overall pattern suggests that spatial clustering is occurring but this does not affect the basic insights and conclusions of the earlier regression work" (Pastor et al. 2004: 434).

The distance-based method is superior to the unit-hazard coincidence method since it takes into account adjacent geographic units that may be affected by the presence of the hazardous waste sites. That nearby units, not just host units may be affected is verified by a number of studies (Nelson et al. 1992; Ihlanfeldt and Taylor 2004; Simon and Saginor 2006). Nelson et al. (1992), for example, examine effects of a landfill on the price of adjacent housing in Anoka county in Minnesota and find that residential property values decline if properties are located within 2.5 miles from the center of a landfill. Ihlanfeldt and Taylor (2004) also examine the relationship between property values and proximity of hazardous waste facilities in Fulton county, Georgia, where the city of Atlanta is located, using individual property as unit of analysis. They find a negative relationship between proximity to the nearest site and property values after the site is listed in CERCLIS or the Georgia Environmental Protection Division's Hazardous Waste Inventory (HWI). However, they find no significant association between density of hazardous waste facility (numbers of hazardous waste facilities within 1.5 mile radius) and decline of property values. They further estimate over $1 billion total property value loss due to hazardous waste facilities in the study area (properties within 1.5 mile

[11] Spatial autocorrelation refers to the violation of an assumption of regression; geographic proximity between observations introduces biases (Gujarati 1995). That is, the regression model assumes that residuals (the unexplained portion from the model) are random. Due to geographic proximity, however, residuals that are systematically associated violate one of the assumptions of regression.

radius from the nearest site). Simons and Saginor (2006) conducted a meta-analysis and reach the same conclusion that hazardous waste facilities reduce nearby residential property values. Given adverse economic effect of hazardous waste facilities on adjacent neighborhoods, exclusion of neighborhoods near such facilities leads to a critical measurement error which yields biased estimates.

In the variation of the distance-based method, Downey (2006) discusses the distance-decay method. The distance decay model calculates decline rates of negative effects of hazardous waste facilities on study areas as distance from facility increases by creating 105.6 foot ($1/50^{th}$ of a mile) resolution of grid cells. That is, as the distance from hazardous facilities increases, impacts of such a facility on grid cells decrease. Using the 2000 TRI facilities and the 2000 US Census data (census tract as unit of analysis), Downey (2006) finds that African Americans are disproportionately burdened by TRI facilities in the Detroit Metropolitan area.

Previous review of literature on environmental inequality on locations of hazardous waste facilities, researchers consistently point out that a growing number of studies find such facilities tend to be located near impoverished and minority neighborhoods (Mohai and Bryant 1992; Goldman 1994; Ringquist 2000; Szasz and Meuser 1997). Recently, Ringquist (2005) conducts a meta-analysis of existing studies pertaining to locational disparity. Results suggest that while environmental inequality exists along a racial line, evidence is relatively weak to suggest that economic class is a significant predictor of the locations of such facilities.

Associations between locations of hazardous waste facilities and racial and socioeconomic conditions of adjacent neighborhoods do not establish causality between the two. In other words, conceivably the siting of hazardous waste facilities could attract impoverished and minority populations given the discounted housing value in those locations. By the same token, it is also possible that hazardous waste facilities could be sited disproportionately near impoverished and minority neighborhoods at the time of siting. Using the 1970, 1980, and 1990 US Census data and toxic storage and disposal facilities (TSDF) whose annual release exceeds 50 tons in Los Angeles County and there upon applying the distance-based method (a quarter of one and one mile radii), Pastor et al. (2001) find that TSDFs tend to be sited near impoverished and minority

neighborhoods rather than that the presence of such facilities tends to attract impoverished and minority populations. Saha and Mohai (2005) also test the same question for TSDFs in the state of Michigan from 1950 to 1990, by applying the distance-based method (1.0 mile radius) to identify temporally differing patterns. That is, whereas TSDFs were not sited near impoverished and minority neighborhoods prior to 1970, the disparate sitting pattern did in fact emerge after 1970. This study implies that increased awareness with regard to environmental problems probably results in disparate siting, and once people become aware of the fact that the presence of such facilities might threaten their well-being they refuse to host them. Due to their unwanted nature, such facilities tend to be located in economically-distressed areas whose inhabitants exercise a low level of political power.

The major focus of environmental justice inquiry focuses heavily on the relationships between locations of environmentally-adverse facilities and racial and socioeconomic conditions of adjacent neighborhoods. In this inquiry, the authors often accept the presence of environmentally-adverse facilities in proxy for environmental risk. To more accurately assess actual levels of risk, a number of studies rely on actual air pollution data (Apelberg et al. 2005; Ash and Fetter 2004; Lejano et al. 2002; Morello-Frosch and Jesdale 2006; Morello-Frosch and Lopez 2006; Pator et al. 2005; Sicotte and Swanson 2007). For example, Lejano et al. (2002) construct a model to exhibit the spatial distributions of health risk in Los Angeles County, California. By using Health Risk Assessment data, calculations of chronic risk from air pollution prepared by the Los Angeles Unified School District, Los Angeles County land use data, and the 1990 US Census data (census tract as unit of analysis), the authors employ the Ordinary Least Square (OLS) to examine the relationship between chronic cancer and non-cancer risks and spatial (i.e., industrial land use) as well as demographic variables (i.e., percent of Hispanics, percent of African Americans, per capita income, and educational attainment). The authors find that the percent of Hispanics and poverty levels tend to increase chances of chronic cancer risk. They also identify 11 vulnerable census tracts that show high risk of chronic cancer and low per capita income, concluding that an understanding of the spatial dynamics of estimated risk and identification of highly vulnerable communities in cities or metropolitan areas are essential for planners because these kinds of information

help to pinpoint where governments should pay additional attention. Similarly, Pastor et al. (2005) examine the relationship between potential lifetime cancer risk and the socioeconomic characteristics of census tracts that rely on the EPA's 1996 National Air Toxics Assessment (NATA) along with the 2000 US Census data. The authors control spatial autocorrelation by introducing space as an independent variable and discover that cancer risk in California is not equally distributed. That is, impoverished and minority census tracts tend to pose a higher cancer risk after controlling for income, occupation, land use, and region. The authors conclude that zoning and land use can explain significant portions of such disparity on the basis of racial composition. Finally, Ash and Fetter (2004) examine relationships between the level of air pollution[12] and the racial and socioeconomic conditions of census tracts in 1990 in urbanized areas. They find that African Americans and the impoverished tend to live in cities and neighborhoods with higher air pollution than their counterparts. Hispanics, on the other hand, tend to live in cities with lower air pollution but live in neighborhoods with higher air pollution.

2-3 New Topics on Environmental Justice

Some researchers are interested in exploring new dimensions of environmental justice. Harner et al. (2002), for example, attempt to construct several indices with which to measure the relationship between distribution of environmental hazards and socioeconomic conditions of adjacent neighborhoods. The Comparative Environmental Risk Index, for example, is computed based on the ratio between the percent of whites and non-whites within a 1.5 mile radius of CERCLIS and NPL sites and a 1.5 mile radius of other environmentally adverse facilities in metropolitan areas. This computation is repeated for Hispanics and persons living below the poverty line. These three numbers are then averaged, after which they are multiplied by the total MSA toxicity rate (toxic sites / total population of MSA * thousand) for normalization purposes in comparing between MSAs. Higher numbers indicate severity of environmental risk. Throughout the article, the authors develop different indices to measure the severity of environmental injustice in MSAs. Lopez (2002) also examines the exposure to toxins of racial economic groups in US metropolitan areas with a population of a million or more in 1990 (N=44). Using the 1990 US Census and EPA toxic release data, the author constructed

[12] The level of air pollution is measured by 1998 US EPA data on toxicity-adjusted exposure to air pollution.

a net differential score, or probability of African American exposure to air pollution comparing to white's exposure of the pollution. This score is constructed by combining direct impact (i.e., release from facilities in census tracts) and indirect impact (release of adjacent census tracts) while considering win patterns. The results suggest that African Americans are more likely than whites to live in census tracts with higher air pollution levels. Specifically, 52% of the score variations can be explained by an index of dissimilarity and percent of persons in manufacturing occupations.

Furthermore, some studies link environmental injustice to urban transportation, arguing that individuals who avail themselves of private transportation should bear more of the bill for vehicle-related air pollution (Grineski et al. 2007; Gordon and Dorling 2003; Houston et al. 2004). Using national data on NOx concentrations and the 1991 UK Census data for demographic variables[13], Gordon and Dorling (2003) find that in high-poverty wards residents who are less likely to own vehicles are more likely to suffer from high level of air pollution. That is, the air pollution in the wards with high vehicle-ownership rates is lower than the air pollution in wards with low vehicle-ownership rates, meaning that those who are more likely to be air polluters in fact enjoy cleaner air in their residential areas. Similarly, Houston et al. (2004) examine the historic and structural process of creating and maintaining environmental inequalities related to transportation systems. Using the 2000 US Census data, 2000 traffic data, and zoning land use maps of four counties (Los Angeles, Orange, Riverside, and San Bernadino Counties) in the Los Angeles metropolitan area, the authors find that road density and traffic density of poor and very poor census block groups are twice as high as non-poor census block groups. Because residents of poor and very poor census block groups show lower percent of vehicle ownership and higher percent of reliance on public transportation for work commutes than do non-poor census block groups, these residents experience disproportional shares of vehicle-related air pollution. In considering racial segregation in poor census tracts, the authors conclude that disproportionate burdens of transportation-related pollution are imposed on the disadvantaged of the Los Angeles metropolitan area.

While the majority of researchers are preoccupied with unequal environmental

[13] The unit of analysis is the ward which is equivalent to US census tract: N=10,444.

burdens imposed on impoverished and minority populations, they often do not adequately address economic factors (i.e., compensation of environmental bads). Jenkins et al. (2004) examine the relationship between the amount of compensation of hosting community and four factors: negative externalities, community participation, employers' financial capability, and socioeconomic composition. Using 1990 US Census data, phone interviews of landfill owners, and Chartwell Information Publishers (directory containing landfills information), the authors find that community participation significantly increases the amount of compensation paid to cities and counties for environmental bads. Especially, participation that entails community knowledge ability about landfills and the presence of a state mandatory host fee are found to be significant predictors of greater amounts of compensation. Socioeconomic variables, on the other hand, are not significant predictors of compensation to cities, though the percent of minority and impoverished inhabitants is found to be significant for compensation to counties. Although this study highlights the importance of community involvement in the decision-making process as to the hosting of landfills, it is unclear whether compensation fees directly benefit adjacent neighborhoods.

In conclusion, reviewing quantitative environmental justice studies yield several conclusions. First, methodological advances, use of the Geographic Information System in particular, improve scientific inquiry, which helps researchers comprehend why inconsistent results were reported in earlier studies on environmental inequality (see Table 2-1). That is, all studies (reviewed in this chapter) employing the distance-based method find that race is not only an independent but also a stronger predictor of locations of hazardous waste facilities from (than) income. Furthermore, environmental justice studies attempt to link various other types of environmental inequality (rather than proximity to hazardous waste facilities) into racial contexts such as residential segregation, cancer risks, and urban transportations. Such a diverse coverage with respect to disproportionate environmental burdens is certain over time to open up the topic to productive interdisciplinary discussions. Such discussions can only enhance conceptual understanding of environmental injustice in the United States as, for instance, of the sociological understanding of residential segregation, the political understanding of power relations and political empowerment, the scientific

understanding of toxic substances and their possible synergetic effects, public health understanding of impacts of toxic substances on public health, and the planning understanding of evolving land uses and zoning and their decision-making mechanisms. In addition to the above, it is critical to determine whether the existence of brownfields constitutes yet another environmental burden on disadvantaged populations. The next chapter will introduce the environmental justice issues relevant to brownfield development, followed by a survey of studies on brownfield development.

Table 2-1 Comparisons of methods in spatial environmental justice studies

Method	Unit-Hazard Coincidence	Distance-Based	Distance-Decay
How to Capture Spatial Units	Host units proper	Specified distance from points of interests (i.e., hazardous waste facilities)	Distances from points of interests to centroid of spatial units
Advantage	Easy to employ	Inclusion of adjacent spatial units that might be affected by points of interests	Differentiation of spatial units by distances
Disadvantage	This method disregards possible impacts of points of interests on adjacent spatial units from host units proper.	Same impact of points of interests on spatial units is assumed if they are captured specified circular buffers from the points.	It is unknown that what degree impacts of points of interest is discounted as spatial units' distances from the points.
Example Study	Anderton et al. (1994)	Mohai and Saha (2006)	Downey (2006)

CHAPTER 3: LITERATURE REVIEW ON BROWNFIELD DEVELOPMENT

As discussed in the previous chapter, environmental justice studies have found that disproportional environmental burdens are imposed on impoverished and minority neighborhoods. In other words, race is not only an independent but also a more significant predictor of locations of hazardous waste facilities than income. In addition to these burdens, the presence of brownfields may well pose an additional environmental burden on these neighborhoods. Environmental justice scholars have been interested in brownfield development and began to identify environmental justice issues on brownfield development (Bullard et al. 2007; Dixon 2003; Greenberg and Lewis 2000; Hula 2002; Kuehn 2000; Mank 2000; McCarthy 2002; National Environmental Justice Advisor Council 1996).

The National Environmental Justice Advisor Council (NEJAC 1996)[1], for example, identified environmental justice issues on brownfield development and provided recommendations. Issues that NEJAC identifies include realization of the confronting the issue of race and class, urban revitalization and community-driven models of redevelopment, and community-based mapping and environmental protection. NEJAC claims that race does matters in many issues such as economic disparity between whites and racial minorities and environmental disparity, or disproportionate environmental burden on minority populations. Thus, policy makers "must find every opportunity to forthrightly confront issues of race and class in American society" (NEJAC 1996: 12). In terms of urban revitalization and community-driven models of redevelopment, NEJAC argues that brownfield development must be a bottom-up process which "proceeds from a community-based vision of its needs and aspirations and seeks to build capacity, build

[1] The National Environmental Justice Advisor Council (NEJAC), established on 1993, is a federal advisory committee to provide independent advice, consultation, and recommendations to the Administrator of the U.S. Environmental Protection Agency on matters related to environmental justice.

partnerships, and mobilize resources to make the vision a reality" (NEJAC 1996: 12). Active participation in the process can reduce gentrification, or displacement of existing residents. Community-based mapping and environmental protection refers to the process that residents shape their own future by actively engaged in decision-making process. Community-based mapping is an idea that residents identify environmental hazards and burdens in their neighborhoods, and such mapping can help them to promote their objections when new environmentally hazardous facilities are sited in their communities in the future. Community-based environmental protection is critical because this concept includes not only ecological but also social/cultural dimensions of local environmental protections. NEJAC (1996) proposes recommendations to deal with issues such as public participation and encouraging community vision in the brownfield development process, preparing environmental standards/liability for public health, and encouraging public and private sector partnerships.

Regardless of descriptive discussions of environmental justice concerns on brownfield development, little effort has been made to date to empirically evaluate such concerns. Furthermore, there is no study to examine racial and socioeconomic disparities of brownfield locations. This chapter, therefore, summarizes environmental justice issues relevant to brownfield development that appear in descriptive brownfield development literature. Empirical studies on brownfield development are then also introduced to examine what types of studies on brownfield development have been conducted.

3-1 Environmental Justice Issues on Brownfield Development

There are several crucial environmental justice issues in brownfield development: (1) the potentially adverse impact of brownfield cleanup, (2) the uncertain economic impacts on local residents, (3) the gentrification displacement of the impoverished, and (4) the uncertain roles of residents adjacent to brownfields in the developmental process. Before discussing those shortcomings, it should be noted that brownfield development is not clearly articulated for environmental improvement purposes. The Clean Michigan Initiative tends, for instance, to consider developmental potential as the main selection criteria for brownfields to be cleaned up for subsequent development (Hula 2002). Lack of articulation of environmental improvement purposes in brownfield development may

prove a reason why environmental justice researchers overlook brownfield development as an environmental justice agenda.

Residents of inner cities have historically suffered not only from the concentration of poverty (Massey and Denton 1993; Wilson 1987; 1996) but also from the location of environmentally hazardous facilities and locally unwanted land uses (Ash and Fetter 2004; Boer et al. 1997; Boone 2002; Lejano et al. 2002; Mohai and Bryant 1992; Pastor et al. 2001, 2004, 2005; Pulido et al. 1996; Ringquist 1997; Stretesky and Hogan 1998; UCC 1987). Considering the existence of environmental disparity along with racial and class lines, the cleanup standards allowed by brownfield development pose a concern. Cleanup standards under brownfield development programs for most U.S. states are generally lower than the Superfund standard for industrial and commercial uses (Fitzgerald and Leigh 2002; Greenberg 2002, 2003; Hula 2002; Mank 2003; NEJAC 1996; Simons and Winson 2002; Solitare and Greenberg 2002). Given the passage of the Brownfield Revitalization and Environmental Restoration Act (BRERA) that provides federal liability exemptions once purchasers meet cleanup standards set up by state and local governments (Hird 2002), they tend to set lax cleanup standards (laxer than ones under the Comprehensive Environmental Response, Compensation, and Liability Act) to provide incentives for brownfield developers. Thus, it is unclear whether lowering the cleanup standards is healthy for adjacent residents. Hula (2002: 18) claims, "There is little question that [an overall lowering of standards] has reduced developer costs. Less clear, however, is the adequacy of the new standards to protect public health." Therefore, if various types of environmental burdens are spatially concentrated and impoverished and minority populations disproportionately live near the sites of such burdens, lowering of the cleanup standards should be reconsidered. In addition to reconsideration of the lowering of the cleanup standards, further studies should be connected with respect to the cumulative impacts of various pollutants on adjacent neighborhoods.

Brownfield development also raises questions as to its potential economic benefits, the key question being whether economic benefits from development are in fact realized in residents in adjacent neighborhoods. Historically, economists have argued that hosting environmentally hazardous facilities can enhance local economic conditions (e.g.,

create jobs and increase local tax revenues), while environmental justice advocates and residents of affected neighborhoods have suspected the promised economic benefits (Kuehn 2000; Mank 2000). With respect to their suspicions, brownfield development is no exception, for as Kuehn (2000) states, "Plans by developers and government entities for redevelopment of the lower income, people of color communities where brownfields are found often have failed to create tangible benefits for local residents" (10700). The General Accounting Office of the United States (GAO 2002) confirms that it is unclear whether local residents are actually hired by industrial facilities in the area. Moreover, despite the high concentration of chemical factories in Louisiana's 'Cancer Valley,' local residents often suffer additionally from high unemployment rates (Bullard 2000). This finding indirectly suggests that local residents may not be to any appreciable degree be hired by local businesses[2].

Even when brownfield development can in fact generate tangible economic benefits to local neighborhoods, another unintended negative consequence arises in the form of gentrification, which involves the influx of relatively affluent newcomer populations to inner cities (Bridge 2003; Lees 2000, 2003; Refern 2003; Smith 1982; Zukin 1982). These newcomers often purchase their ubiquitously-located properties on the cheap and then renovate them. The influx of such population segments and the improvement of the properties they acquire tend to increase the overall property values or rents in adjacent areas. But because existing residents are most likely to come from impoverished racial minorities they subsequently cannot afford the increased property taxes or rents and thus often face residential displacement (Chambers 2002; Kuehn 2000). Displacement poses a serious problem because the displaced often end up in neighborhoods of even lower environmental, economic, and social quality than the ones in which they previously resided.

Finally, brownfield development is often implemented via a property-specific

[2] Local residents are excluded from the local labor market for various reasons. However, some scholars posit that labor market discrimination could be one of the crucial reasons for impoverished and minority inner-city residents often being excluded from labor markets (Ihlanfeldt 1999; Kasinitz and Rosenberg 1996; Meiklejohn 1999; Neckerman and Kirschenman 1991; Pager 2003; Turner 1997). One experimental study (Pager 2003) finds that being an African American in the U.S. is equal to whites with criminal records in the labor market. In other words, African Americans without criminal records show the similar probability of being hired as do whites with criminal records. This study provides strong evidence that racial prejudice exists in the labor market.

development effort in the absence of cooperation in the community planning process (Dixon 2003; Fitzgerald and Leigh 2002; Garson 2002; Hula 2002; National Environmental Justice Advisor Council 1996; Simons and Winson 2002). The challenge thereby involves incorporating brownfield development within the larger framework of community planning and development. The critical aspect of this issue lies in public participation in the development process, as noted by the claim of Cole and Foster (2001) that racial minorities and lower-income residents are often excluded in governmental environmental decision-making processes, a fact which raises concerns for procedural justice. English (1999: 36) also stresses the importance of public participation in the community planning process in holding that, "Open processes inviting participation of members of the community are no magic bullet, but they improve the chances that the resulting plans will be consulted in making future decisions." The question needful of answering lies in "[to] what extent local neighborhoods should be involved in local redevelopment efforts" and how the desired level of public participation in brownfield development can be achieved in the absence of strict formal requirements (Hula 2002: 18). Some scholars (Dixon 2003; Greenberg 2003; Hula 2002; McCarthy 2002) argue that brownfield development should be incorporated into broader community planning efforts for the purpose of community mobilization. McCarthy (2002) reports that Powers et al. find that public participation in the brownfield development process produces faster and more reliable outcomes.

In conclusion, Hula (2001) anticipates that brownfield development can be an excellent alternative for a new toxic waste policy in the United States, and many others appear to agree with him because brownfield development aims at environmental as well as economic improvements (Fitzgerald and Leigh 2002; Simon and Winson 2002). However, it is too premature to overstate the benefits of brownfield development based on potential rather than actual effects. That is, despite the immense potential of brownfield development, there are many problems associated with it. Environmental justice issues identified in the above include; (1) who lives near brownfield sites; (2) whether jobs created will given to local residents; (3) whether lowering the cleanup standard is safe for human health; and (4) what roles should be played by affected residents from brownfield developments. Those are important questions that need to be

answered in assessing the actual impact of brownfield development on local neighborhoods. The next section reviews studies to date on brownfield development.

3-2 Studies on Brownfield Development

There are three broad themes in previous studies with respect to brownfield development: the developer/governmental perspective, the resident-oriented perspective, and the legal/political aspects of brownfield development[3]. The developer/government perspective on brownfields includes the process of brownfield development (Fitzgerald and Leigh 2002; Howland 2003; Simon and Wilson 2002), the perception of developers and/or governmental officials regarding development of contaminated properties (Alberini et al.; De Sousa 2005), and the roles of contamination in market transactions (Howland 2004; Pryce 2003; Schoenbaum 2002; Yount 1997). The resident-oriented perspective of brownfield development includes the locations of brownfields (Solitare and Greenberg 2002), the city-wide impacts of brownfield development (Greenberg et al. 2000; De Sousa 2005), and the preferences of residents in terms of brownfield usage (Greenberg et al. 1999; Greenberg and Lewis 2000). The legal/political aspects of brownfield development address questions such as whether state-initiated Voluntary Cleanup programs are violations of the Title VI of the Civil Right Act (Mank 2003) or how brownfield development can be linked to broader community development goals including public participation in the process of brownfield development (Dixon 2003; Hula 2002; McCarthy 2002) and/or growth management-related endeavors (Greenberg et al. 2003).

3-2-1 Developer/Governmental Perspectives

In terms of the process of brownfield development, many studies deal with the process that leads to successful brownfield development (Fitzgerald and Leigh 2002; Howland 2003; Simon and Wilson 2002). Successful brownfield development is frequently defined as completion of site cleanup, after which new businesses move in[4]. With the case study method, typical research questions in these studies involve how development projects have been pursued, whether properties are fully renovated or

[3] Taxonomy provided is based on author's understanding and judgment of brownfield literature, and some might not agree with such a taxonomy. Readers should thus bear in mind that categorizations of literature are suggestive rather than conclusive.

[4] These studies do not include the use of local residents as a component of successful brownfield development. Furthermore, all studies cited the above define success cases as the same manner.

developed such that new businesses can operate, and how many governmental subsidies have been granted the development. Howland (2003), for example, examines three brownfield sites in Baltimore, Maryland, and notes that two of the three sites zoned for industrial uses have in fact been renovated and currently are in use. On the other hand, a brownfield site zoned for residential uses have difficulty in getting the development completed. He observes that a stringent cleanup standard imposed on residential uses up limited feasible options available to a developer when unexpected additional contaminations arise. Subsequently, developer in this study pulled out from the voluntary cleanup program in the absence of room to negotiate with respect to the additional cost of cleanup for contamination. Although Howland (2003) notes that one developer's inexperience in brownfield development contributed to its failure, the stringent cleanup standard was considered as the major reason for project incompletion. Similarly, Fitzgerald and Leigh (2002) also introduce successful brownfield development cases identified by the EPA as successful cases and describe how they were processed.

In terms of the perception of developers and governmental officials in developing contaminated properties, studies deal with questions such as whether developers hesitate to invest in previously contaminated sites and whether there are perceptual differences between private and public stakeholders in brownfield developments. Alberini et al. (2005), for instance, survey private real estate developers and find that past contamination does not deter redevelopment of previously contaminated properties. The authors additionally find that liability relief is stronger incentive than the simple financial subsidies provided by governments. Although this study sheds light on perceptions of private developers engaging in development activities, the majority of respondents come from European countries where legal structures are different from those of the US. Therefore, caution should be exercised when interpreting the findings of this study. De Sousa (2005), for another example, interviews the stakeholders (private as well as public) and reveal that economic factors (i.e., whether or not profits or revenues can be generated) are the dominant reasons for involvement in brownfield development. The stakeholders report that high costs and limited governmental support is the major obstacle for their investing in brownfield properties. Respondents report

that governments should secure stable funds for brownfield development and should as well simplify developmental procedures (i.e., elimination of procedural sluggishness) in order to increase policy effectiveness. Finally, the author finds that respondents generally agree that brownfield development should be connected to a broader sustainable development framework.

Finally, some researchers are interested in the roles of contamination in market transactions (Howland 2004; Pryce 2003; Schoenbaum 2002; Yount 1997). This is an interesting topic because hazardous waste facilities reduce property values of adjacent area (Nelson et al. 1992; Ihlanfeldt and Taylor 2004; Simon and Saginor 2006). Therefore, some might believe environmental contamination might reduce market transactions; hence, polluted properties tend to be abandoned or underutilized. Studies suggest that environmental contamination played limited role in market transactions of properties. Howland (2004), for example, examines whether contamination influences sales and selling prices of contaminated parcels (N=45) in southwest Baltimore, for one industrial area. He finds that contamination is not the main factor when a parcel remains unsold because the market reflects contamination in reduction of prices of such parcels. Rather, characteristics of unsold parcels tend to be their small and odd shapes, obsolete infrastructure (i.e., served by a narrow road and lacking telecommunications connections), and incompatible surrounding land uses. Similarly, Schoenbaum (2002) finds that contamination alone does not explain unused or underutilized brownfield sites in Fairfield, an industrial area in Baltimore. The author investigates parcel records from 1963 to 1999 and finds no systematic relationships between environmental contamination of a parcel and assessed value, land vacancy, property turnover, and economic development.

3-2-2 Resident-Oriented Perspectives

A numbers of studies focus on resident-oriented brownfield development, and these compare socioeconomic characteristics of cities or municipalities that have brownfield properties (Greenberg et al. 2000; Solitare and Greenberg 2002). The studies fail to examine the impacts of brownfield properties on the neighborhood level. Greenberg and colleagues (2000) examine the impacts of brownfield properties on adjacent properties by surveying local officials in all the municipalities (566) in the state of New

Jersey[5]. Among 454 cities and municipalities responding to this survey, 146 cities and municipalities claim at least one brownfield property. Based on tax assessor knowledge, 15 brownfield properties (major impact brownfields) have experienced adverse impacts (i.e., decline in property values) spreading beyond a quarter mile. Cities and municipalities that have major impact brownfields are considered socioeconomically disadvantaged. Solitare and Greenberg (2002) compare cities that received EPA brownfield assessment pilot grants with ones which did not receive such funding. Because brownfield development aims to improve the socioeconomic conditions of adjacent neighborhoods, the authors reason that grants should be distributed among cities suffering the poorest socioeconomic conditions. It appears that the authors assume brownfield redevelopment leads to improving socioeconomic conditions, which might not be an appropriate assumption. An independent sample T-test reveals that cities receiving such grants tend to be socioeconomically disadvantaged. Based on this finding, the authors conclude that the brownfield assessment pilot grant funds are justly distributed[6].

With respect to studies examining outcome of brownfield development, De Sousa (2005) uses a brownfield database provided by the state of Wisconsin and finds that the city of Milwaukee created or retained 2,200 full-time and part-time jobs and generated revenues of $325 million in 64 projects, each project thus generating approximately $5 million. It is unclear, however, whether local residents in fact became beneficiaries (in terms of employment opportunities) of the development.

Then there are the studies that deal with the preferences of residents in the community development process. Greenberg and Lewis (2000) survey residents living near brownfield properties in Perth, New Jersey, and find that residents are not likely to prefer commercial and industrial development of adjacent brownfield properties. Rather, they prefer recreation facilities such as neighborhood parks and community centers

[5] The authors rely on knowledge of municipal tax assessors when brownfields are classified. In this study, tax assessors were instructed not to include any abandoned gas stations as brownfields. The major impacted brownfields are termed TOAD (Temporarily Obsolete Abandoned Derelict Site).

[6] In this study, the unit of analysis is the city or municipality. The authors compare socioeconomic conditions of various groups. Cities or municipalities with EPA grants are compared to ones without EPA grants. Moreover, cities or municipalities with EPA grants are compared to those without EPA grants in the same states. The final comparison groups were chosen based on similar demographic and economic characteristics of cities or municipalities with EPA grants versus ones without EPA grants.

followed by affordable housing. In this survey, the authors find that although about 75% of the respondents are willing to participate in the brownfield development process, only 20% of the respondents have been actively involved in civic activities in the past two years. Greenberg (1999) also summarize the results of previous surveys, reporting that industrial and commercial development tends to lower residents' perceptions of neighborhood quality unless the development directly benefits their neighborhoods (i.e., provision of employment opportunities). In this study, the authors survey residents in the state of New Jersey with respect to their perception of neighborhood quality and find that crime, blight, and physical decay are negative factors in neighborhood quality. That is, without actually dealing with those problems (crime, blight, and decay), their perceptions of neighborhood quality is unlikely to improve. Interestingly, local residents do not want brownfield properties to be developed for commercial and industrial purposes, possibly because they knew that conventional economic development will not provide employment opportunities for them. Therefore, local residents do not want commercial and industrial development which provides few economic impacts on their neighborhoods at the same time as lowering their perceptions of neighborhood quality[7].

3-2-3 Legal/Political Perspectives

In terms of the legal/political aspects of brownfield development, Monk (2000) argues that state-initiated Voluntary Cleanup programs are vulnerable to lawsuits on the basis of Title VI of the 1964 Civil Right Act, which prohibits discrimination based on race, color, or national origin in any program or activity of a federal financial assistance recipient (Eady 2003). In other words, brownfield programs in most states allow lower cleanup standards when the use will be commercial or industrial. Coupled with the fact that minority populations tend disproportionately to live near brownfields, those programs produce disproportional impacts on minority populations, which is interpretable

[7] One study suggests conflicts between local residents and governmental officials in the process of local economic development (Jennings 2004). When the city of Boston proposed a bio-tech company in the impoverished African American neighborhood of Roxbury, coalitions among Roxbury residents, neighborhood organizations, the Roxbury Neighborhood Council, and the Boston Redevelopment Authority successfully prevented approval of the biotech company through the Roxbury Master Plan process in which local residents played the critical role of defining clear community interests for future land uses. Instead of outside companies, community residents could successfully argue for small local businesses, affordable housing, and safe neighborhood parks. What residents wanted in this study is consistent with the study introduced above (Greenberg and Lewis 2000).

as a violation of the Civil Right Act (Monk 2000). Although it is reasonable to claim that brownfields are located near impoverished and minority neighborhoods given the historic economic decline of US central cities, there is no study to date to scientifically evaluate such disparity. Many environmental justice lawsuits have relied on Title VI of the Civil Rights Act in winning their suits (i.e., Chester, Pennsylvania: Cole and Foster 2001; Monk 2000). However, the application of Title VI of the Civil Rights Act has in recent years become attenuated (Stephens 2005). In 2001, the US Supreme Court held that private citizens did not have the legal standing to enforce the Title VI ruling in an unrelated Alabama case (Eady 2003). After this decision, a number of complaints based on Title VI claims were judicially denied[8].

Greenberg and his colleagues (2001) claim that brownfield development is one of the most viable smart growth options, the central theme of smart growth or growth management endeavors being to reduce suburban sprawl by inducing development in urban areas where development has already occurred. The advantages of brownfield development as a smart growth option are environmental improvement, economic feasibility, and reduction of economic disparities between cities and suburbs. Brownfield development enhances air and water quality by reducing the number of private automobiles due to the compacting of urban forms and the preserving of open spaces in suburban areas, respectively. Furthermore, the cleanup of contaminated properties reduces potential threats to public health. Considering that many smart growth options often impose restrictions on development[9], brownfield development is more economically feasible given that economic improvement of adjacent areas can be

[8] Before the Alabama case, the federal district court of New Jersey ruled in 2001 that the New Jersey Department of Environmental Protection failed to perform an adequate Title VI analysis, and the court granted a preliminary injunction against construction of a cement plant to the plaintiff, the South Camden Citizens in Action companied (Eady 2003). After the Alabama case, however, the Third Circuit Court of Appeals voided its previous decision and allowed the cement company to begin operation. Because the court interpreted that the right of the South Camden Citizens in Action to sue the government for enforcement came from federal regulations and not from Title VI itself, private citizens were prohibited from suiting to enforce the EPA Title VI regulations (Pomar and Godsil 2006).

[9] Two popular smart growth options are purchasing development rights from property owners whose properties are located in environmentally sensitive areas and imposing impact fees. When developmental rights are purchased, uses of such properties are limited with the exception of agricultural activities (Stokes et al. 1997). Many local governments imposed impact fees for suburban properties to compensate governmental costs of providing infrastructure such as water and sewers (Kelly and Becker 2000; Porter 1997; Zovanyi 1998). The basic idea behind these two approaches lies in the fact that sprawl will be reduced if it proves difficult and costly to develop suburban areas.

expected. It is also anticipated that brownfield development can reduce economic disparities between cities and suburbs. Suburban sprawl is in fact responsible for increasing economic disparities between cities and suburbs given that it attracts the wealthy to suburbs and leaves the impoverished in cities (Orfield 1997; Rusk 1997; 2000). Thus, brownfield development is capable of reducing social and environmental injustice.

Regardless of its advantages, brownfield development poses a considerable dilemma (Greenberg et al. 2001). Too-flexible cleanup standards can harm the comparative advantage of public health given inadequate cleanup while too-inflexible cleanup standard can reduce the comparative advantage of economic feasibility given blocking the economic development of contaminated properties. By the same token, too-stringent cleanup standards could lead to project delays, resulting in brownfield development's losing comparative advantage over greenfields as discussed in Howland's study (2003). Accordingly, policy makers and urban planners should be aware of the tradeoffs of developing and implementing effective and efficient brownfield policies.

Although brownfield development can be a tool to reduce suburban sprawl and social and/or environmental injustice, there are several issues that must be considered. As discussed, brownfield development must provide direct economic benefits to local residents to reduce economic and social disparity between city and suburb. Furthermore, as discussed, gentrification must be controlled. If existing impoverished residents are displaced by relatively wealthy newcomers, it is difficult to claim that brownfield development reduce economic and social disparity between city and suburb. Therefore, when brownfield development is employed as a smart growth tool, policy makers and planners should deal with the two issues.

Finally, McCarthy (2002) claims that brownfield development faces challenges in terms of land use policy. Whereas brownfield development should eliminate or reduce barriers that prevent brownfield properties from being developed, brownfield development should correspond to broader community goals, a daunting challenge given that the preference of local residents differ from those of local politicians and policy makers. While local residents prefer to have community-oriented facilities such as parks or community centers, politicians and policy makers prefer commercial and industrial facilities capable of creating revenues for their jurisdictions (Greenberg and

Lewis 2001). Therefore, public participation is critical in the process of brownfield development, and many scholars agree that public participation in brownfield development is important (Dixon 2003; Greenberg et al. 1999, 2000; Greenberg and Lewis 2001; Hula 2002; McCarthy 2002). However, it is equally important that the public should be involved in the decision-making process. In the planning literature, public participation is often held in the late phase of the decision-making process (Jarobe 1986; Plein et al. 1998; Tauxe 1995), limiting the degree of influence that participants can exercise given that most of the decisions will already have been made. In this respect, public participation in the planning process is often misused to legitimize decisions or avoid responsibility when goals are not achieved. Thus, McCarthy (2002) asserts that early involvement of local residents is crucial for successful brownfield development[10].

Although these are crucial topics in brownfield development, contemporary brownfield research is devoid of small-scale analysis in brownfield development. In other words, it is not scientifically proven that brownfields are located in impoverished and minority neighborhoods within a metropolitan area, a city, or municipality. Furthermore, previous studies suggest that the presence of brownfields influences subjective opinions of neighborhood quality as reported by local residents. However, it is to date unclear whether the presence of brownfields influences the socioeconomic conditions of adjacent neighborhoods. Finally, also unclear is whether positive externalities were generated by governmental economic development policies, that is, whether the socioeconomic conditions of local neighborhoods show improvement after governmental economic development policies have been implemented. The next chapter will introduce theoretical frameworks and hypotheses of this dissertation.

[10] The most compelling reason for public participation in the decision-making process lies in the democratic nature of decision-making. However, one study indicates that public participation can improve the quality of decisions given the contributions of unique knowledge of local residents (Corburn 2003).

CHAPTER 4: THEORETICAL FRAMEWORKS

The theoretical frameworks of this dissertation consist of two bodies: borrowing from environmental justice literature and synthesizing sociological theories. For locations of brownfields and changes in socioeconomic status of adjacent neighborhoods (research question 1 and 2), new theoretical explanations will be developed based on synthesizing sociological theories; they are concentration of poverty, residential segregation, and deindustrialization. In regard to cleanup prioritization (research question 3), theories from environmental justice literature will be used; they are the sociopolitical theory including the resource mobilization theory and indirect institutional discrimination. This chapter discusses a new theoretical framework to explain racial and socioeconomic disparities of brownfield locations followed by reviewing existing theories to explain racial and socioeconomic disparities of brownfield cleanup prioritization.

4-1 Locational Disparity of Brownfields

Environmental justice studies often find that hazardous waste facilities tend to be located near impoverished and minority-concentrated neighborhoods, and three theoretical explanations are offered (Mohai and Saha 2007; Saha and Mohai 2005). First, the rational choice models are one of the reasons why such facilities tend to be disproportionately located near impoverished and minority-neighborhoods. Because cheap land is often available near such neighborhoods, facilities owners tend to site their facilities near these neighborhoods (Mohai and Saha 2007; Saha and Mohai 2005). Second, sociopolitical models offer an explanation why hazardous waste facilities tend to be disproportionately located near impoverished and minority-neighborhoods. Because residents in impoverished neighborhoods need employment opportunities, governments tend to grant siting permits of hazardous waste facilities in hopes for economic benefits from these facilities. In addition, governments often grant siting permits of hazardous waste facilities in impoverished and minority neighborhoods because residents in these neighborhoods possess weak political power (Mohai and Saha 2007; Saha and Mohai

2005). Third and finally, racial discrimination models are also considered as a reason for racial disparities of locations of hazardous waste facilities. Discrimination against minorities in past led socioeconomic disparities between whites and minorities, which in turn led those locational disparities (Mohai and Saha 2007; Saha and Mohai 2005). More detailed discussion with respect to indirect institutionalized discrimination (Feagin and Feagin 1987) will be followed in the next section.

The first two explanations do not provide sufficient explanations of why brownfields are spatially concentrated and why neighborhoods adjacent to high concentrations of brownfields might experience socioeconomic status decline over time. For example, because owners of brownfields abandoned not sited their facilities, rational choice models do not directly introduce environmental burdens into nearby neighborhoods. Moreover, because no governmental permit is required for facilities to leave from one place to others, the claim that sociopolitical models contribute to locational disparities of brownfields make little sense. The key component of brownfield locations lies in why facilities are abandoned rather than sited. As a result, the creation of brownfields should be seen as concomitant of societal change rather than the intentional acts of facility owners or governments. Thus, rather than relying on siting disparity theories, theories must be synthesized to explain brownfield locations. Deindustrialization, spatial concentration of poverty, and residential segregation can provide more direct answers to such questions.

Spatial concentration of poverty along with structural and spatial deindustrialization go a considerable way toward explaining why brownfield properties are disproportionately located in impoverished and minority neighborhoods. Spatial deindustrialization refers to the relocation of industrial facilities to other sites within the U.S. (deindustrialization of central cities: Wilson 1987) and structural deindustrialization refers to the relocation of industrial facilities to foreign countries, and especially Third World countries experiencing the pressures of globalization (deindustrialization of the US society; Davey 1995). That is, spatial deindustrialization represents the spatial rearrangement of manufacturing facilities within the U.S. (from central cities to suburbs or from one state to another) whereas structural deindustrialization represents the transformation of U.S. society from industrial to post-industrial. The availability of

cheap land may be one reason for the occurrence of industrial suburbanization (Fernandez 1994; Sugrue 1996). Further, financial incentives appear to be a reason for interstate relocation of industrial facilities (Ledebur and Woodward [1990] 1999). In terms of international relocation, a cheap labor pool and lax environmental regulation can constitute reasons for U.S. companies to relocate their plants abroad (Kletzer 2000; Simon 2000; Sugrue 1996). Because the U.S. has stringent environmental regulations, full compliance can prove difficult due to the high costs. Further, U.S. labor costs are higher than those of Third World countries. In this light, multinational corporations may have been enticed by cost-saving opportunities to relocate their manufacturing plants to Third World countries in which an abundant supply of cheap labor and lax environmental regulation are available. In short, the relocation of manufacturing facilities from central cities to various new locations has left many potential brownfield properties in central cities though not all such facilities went on to become brownfields.

In particular, deindustrialization in the Detroit region and found that suburbanization of manufacturing plants occurred as early as the 1950s (Boas 1961; Sugrue 1996; Wheeler 1971). Ford and General Motors relocated their assembly plants from the city of Detroit to suburbs in the early 1950s, followed by Chrysler in the late 1950s. It appears that automation has resulted in the suburbanization of such plants. That is, installation of automated assembly lines requires new spatial layouts that are difficult to install in existing Detroit facilities; thus, new assembly plants were built in suburbs that have been specifically designed for automated assembly lines. However, Sugrue (1996) claims that one covert reason for the suburbanization of manufacturing plants is to weaken the power of the unions. Lee (2005) also finds that union power is generally inversely associated with the degree of deindustrialization in nations. Finally, because highways are capable of transporting goods from one place to others with relatively fast and cheap, the construction of highways of the 1950s and 1960s might also have contributed to suburbanization of manufacturing facilities (Farley et al. 2000).

Whatever the actual reasons, suburbanization of plants led to subsequent suburbanization of independent auto-suppliers for the Big Three companies (Ford, GM, and Chrysler). Because of poor provisions of transportation in the mid-20th century, suppliers were often necessarily located near the location of the buyers. Geographic

proximity of industrial facilities sometimes generates mutually beneficial effects (Saxenian 1994). Thus, although the Big Three companies initiated suburbanization of their manufacturing plants in the 1950s, the decline of manufacturing establishments in Detroit became visible in the 1960s when independent auto suppliers for the automobile companies moved to where the Big Three assembly plants moved (Sugrue 1996). The decline in manufacturing establishments in Detroit provides supporting evidence. Manufacturing establishments in Detroit had been relatively stable from 1947 to 1963 (from 3272 in 1947 to 3370 in 1963). However, the number began to noticeably decline, falling from 3370 firms in 1963 to 1954 firms in 1977 (See Table 2-1). Manufacturing employees in Detroit also declined after 1967, from 209 thousand employees in 1967 to 153 thousand employees in 1977.

In terms of manufacturing establishments and their employees in the tri-county area (Macomb, Oakland, and Wayne), it becomes apparent that many manufacturing jobs had been relocated from the city of Detroit to suburbs. In 1947, there were 3272 and 1493 manufacturing establishments in city of Detroit and its suburbs, respectively. However, suburban manufacturing establishments (3653) outnumbered city's ones (3370), and gap between the two became greater in 1992 (see Table 2-2). The total employees in manufacturing show the same pattern, suburban employees in manufacturing began to outnumber city's ones from 1963 until 1992 (see Table 2-2).

A close examination of manufacturing facilities in Detroit reveals an interesting pattern. In 1967, Detroit experienced urban riots that lasted four days. This riot caused 43 dead, 467 injured, over 7200 arrests, and more than 2000 buildings burned down (Farley et al. 2000; Sugrue 1996). When examining declines in manufacturing facilities in Detroit closely, Detroit lost 423 facilities (or 12.3% decline) in the pre-riots period (from 1963 to 1967). In the post-riots period (from 1967 to 1972), however, Detroit lost 549 facilities, or 18.6% decline (see Table 4-1). The city of Detroit continued to lose manufacturing facilities. For example, the city lost 444 manufacturing establishments between 1972 and 1977, approximately a 19% decline (see Table 4-2). Because the inauguration of the first African American mayor, Coleman Young in 1974, might have scared white manufacturing facility owners, this could be a reason for the continual decline in manufacturing establishments in Detroit after 1972. Therefore, it

appears that the Detroit riots in 1967 and the emergence of the Coleman Young administration might have accelerated the process of suburbanization of manufacturing facilities in the 1960s and 1970s. In short, although automation coupled with cheap available land in suburbs contributed to industrial suburbanization in the broader sense, two crucial historic events might provide a reason why industrial suburbanization accelerated in the late 1960s and 1970s.

Then, what socioeconomic impact deindustrialization rendered in inner city neighborhoods? Spatial and structural deindustrialization leads to pervasive joblessness in central city neighborhoods where manufacturing facilities were once located. Pervasive joblessness in inner city neighborhoods also results in the concentration of poverty. There are two perspectives on the links between deindustrialization and the subsequent spatial concentration of poverty: selective out-migration and residential segregation. Wilson (1987) claims that the Civil Rights Movement of the 1960s opened up social opportunities for minorities, especially for African Americans who had historically been singled out for discrimination. To avail themselves of the new opportunities, most working class and middle class African Americans relocated from their inner city neighborhoods to the white suburbs for improved housing and social opportunities. This exodus of the working and middle classes from inner city neighborhoods (selective out-migration) then creates a social vacuum in which residents of disadvantaged neighborhoods suffer from a lack of social institutions and role models. Lack of a social buffer makes juveniles particularly vulnerable when few adults are able to play an appropriate role model for them.

Per Wilson (1987), the exodus of working and middle class African Americans from inner city neighborhoods coupled with deindustrialization generate the so-called 'concentration effect,' or the development of undesirable and/or antisocial behaviors consequent to social isolation from mainstream white culture. Later, Wilson (1996) identifies social network deficiencies as a reason for the high level of joblessness experienced by inner city residents. In other words, residents who are already gainfully employed could provide valuable insights with respect to employment, such as what employers expect from employees, how job prospects should approach the interview, and where jobs are to be found. Because most inner city residents are not gainfully

employed or are employed in low-paying jobs while most working and middle class people who are likely to possess this information have departed for the white suburbs, the jobless residents of inner city neighborhoods have a hard time availing themselves of employment opportunities. It is apparent that persistent inner city joblessness resulting from plant relocations and closures in league with the absence of neighborhood role models then leads to a high rate of poverty.

Massey and Denton (1993) argue that concentrations of poverty do not result from the selective out-migration of working and middle class African Americans from inner city neighborhoods. Rather, residential segregation is responsible for creating concentrations of poverty. If the exodus of the working and middle classes coupled with the departure of manufacturing plants from central cities are together responsible for concentrations of poverty in inner city neighborhoods, why did these disproportionately impact African Americans and not whites? They claim that residential segregation locks impoverished residents into geographically confined areas, the inner cities, and thus they are unable to go where jobs go because of segregation. At this point, residential segregation provides a valuable backdrop for the spatial mismatch hypothesis. It posits that high levels of inner-city joblessness often result from the fact that inner-city residents are unable to move where the new manufacturing jobs moved after the 1960s. This then creates a mismatch between the locations of jobs and the people needing these jobs (Beggs et al. 1997; Blumenberg and Manville 2004; Fernandez and Su 2004; Fong et al. 2005; Gottlieb and Lentnek 2001; Ihlanfeldt and Sjoquist 1998; Kasarda 1989; Mouw 2000; Raphael 1998a; 1998b; Stoll et al. 2000). Due to this mismatch, inner city residents can be seen to suffer from high levels of joblessness leading to high levels of poverty.

In Detroit contexts, the riot of 1967 and inauguration of Coleman Young has played important role in housing segregation against African Americans (Farley et al. 2000; Sugrue 1996). Because whites might perceived that Detroit was not the safe place to live from the riot of 1967, they might subsequently have relocated themselves to suburbs. The former Detroit Mayor, Coleman Young launched on his mayoral campaign on the basis of race, crime, and police and easily defeated his rival white candidate, John Nicholas in the 1973 mayoral election due to the continuing exodus of whites (Farley et

al. 2000). In this vein, the inauguration of Coleman Young might have fortified the beliefs of whites that Detroit was not the safe place to live and led them to leaving the city. Concentration of poverty in Detroit's African American neighborhoods became evident in the 1970s and 1980s (Farley et al. 2000; Sugrue 1996) because of deindustrialization and residential segregation against African Americans.

In terms of empirical evaluation, residential mobility studies find that both selective out-migration and residential segregation are supported (Crowder and South 2005; Morenoff and Sampson 1997; Quillian 1999; South and Crowder 1997). That is, working and middle class African Americans do leave core areas of the inner city (selective out-migration); however, the arrival of working and middle class African Americans at white suburbs impels whites to leave for other suburbs of metropolitan areas, which only serves to maintain residential segregation for the working and middle class African Americans (residential segregation). Inferring from residential mobility studies, the differences between selective out-migration and residential segregation result in failure to understand the spatial dynamics of neighborhood change. Wilson for one fails to understand the process of neighborhood change (i.e., the influx of African Americans does result in the out-migration of whites) while Massey for another fails to consider the prior racial composition of African American working and middle class neighborhoods which he claims to be segregated. With respect to Detroit, Surgue (1996: 269) stated that whites "reminded reluctant to live in racially mixed neighborhoods, and even when middle-class African Americans moved into prosperous suburbs like Southfield, just north of Detroit, the white population has fled, creating new segregated enclaves."

In order to combine selective out-migration and residential segregation in completing the mechanism that suggests the ways in which poverty is spatially concentrated, the context of time is important. That is, due to historical residential segregation prior to the 1960s, residential areas for minority populations were very limited and found mostly in inner city neighborhoods. However, given the Civil Rights Movement, relatively wealthy minorities could afford to escape from ghetto areas, leaving impoverished residents behind (selective out-migration). Having left them, poor minority residents in inner-city neighborhoods were unable to move due to the

class and racial segregation. Therefore, residential segregation after the 1970s does not appear to provide a cohesive explanation of why poverty is spatially concentrated. Rather, historical residential segregation patterns play a critical role in generating spatial concentration of poverty.

There is a study, however, that suggests why race might be a stronger predictor than income of brownfield locations. Morenoff and Sampson (1997) examine the relationship between population loss and violent crime in Chicago from 1970 to 1990 taking into account of concentration of socioeconomic disadvantage. Using the 1970, 1980, and 1990 census data along with homicide records having geographic identifiers, the authors employed multivariate analysis to find that relatively wealthy African Americans who presumably moved from ghetto areas do not live far from such areas. This finding suggests that relatively wealthy African American populations might live near brownfields compared to white populations of similar socioeconomic status. In other words, while historical residential segregation explains why poverty is spatially concentrated in inner-city neighborhoods, contemporary residential segregation can explain why relatively wealthy African Americans suffer from disproportional environmental burdens including the locational disparity of brownfields.

Spatial and structural deindustrialization and concentration of poverty can also explain why brownfield properties might be spatially concentrated. According to a model of local economy (Blakely and Bradshaw 2002), local economy is built upon basic industries which are the main source of the economic revenue such as taxes for local governments and income for local residents. Furthermore, there are many supplemented industries which rely on basic industries. Finally, local service industries are generated to meet service needs for local residents. Applying this model to the Detroit region, basic industries can be the Big Three companies while supplemented industries can be auto part suppliers for the Big Three. Finally, local service industries are various types such as gas stations, body shops, junk yards, and restaurants. In terms of the present analysis, category 1 brownfield will refer to basic and supplemented industries where as category 2 brownfield will mean local service industries.

Because deindustrialization left category 1 brownfield in inner city areas to become potential brownfields, many more brownfields may have been generated from the spatial

concentration of poverty due to deindustrialization. When poverty is concentrated in inner city neighborhoods, residents thereof lose their purchasing power to sustain local businesses. Loss of purchasing power leads to sluggishness of the local economic base, which in turn results in relocations and/or closures of local businesses. When businesses are relocated and/or closed, some local businesses such as gas stations, body shops, and junk yards have the potential to become category 2 brownfield. In short, spatial and structural deindustrialization suggest that the category 1 brownfields (mostly large manufacturing facilities) were generated by the function of a new social and spatial order (deindustrialization) independent from the racial and socioeconomic conditions of adjacent neighborhoods. When the category 1 brownfields were generated, the category 2 brownfields (mostly small service facilities such as gas stations) were created because of the decline of socioeconomic conditions of the neighborhoods triggered by the category 1 brownfields. Thus, it is reasonable to hypothesize that brownfields may be spatially concentrated (see Figure 4-1 for timeline of deindustrialization and its consequences).

According to Wilson (1987, 1996) and Massey and Denton (1993), concentration of poverty in inner-city neighborhoods started in the 1970s with the start of deindustrialization. Morenoff and Tienda (1997) find that relatively few underclass neighborhoods existed in Chicago as of 1970. However, underclass neighborhoods increased remarkably during the 1970s and 1980s. Specifically, there were 22 neighborhoods categorized as underclass in 1970, but that number grew to 187 and 256 in 1980 and 1990, respectively. Once neighborhoods became underclass neighborhoods where poverty and joblessness are concentrated, it is unlikely that they will cease to be underclass neighborhoods in subsequent decades. In the same study, Morenoff and Tienda (1997) find that only two out of 22 underclass neighborhoods in 1970 became non-underclass neighborhoods in 1980. That is, only eleven out of 187 underclass neighborhoods in 1980 managed to upgrade their socioeconomic conditions to become non-underclass neighborhoods by 1990. My own analysis of the Detroit region yields similar results. Considering high concentrations of brownfields in which poverty is concentrated, it is reasonable to hypothesize that the concentration of brownfields can be a predictor of dramatic decline in the socioeconomic conditions of adjacent

neighborhoods between 1970 and 1980. Subsequently, such neighborhoods remained socioeconomically impoverished neighborhoods in the years up to 2000.

4-2 Cleanup Prioritization of Brownfields

Sociopolitical theory, resource mobilization, and indirect institutionalized discrimination are relevant for the third research question; whether brownfield cleanup prioritization is associated with socioeconomic characteristics of nearby neighborhoods. Saha and Mohai (2005) give a sociopolitical explanation for the disparity in siting of hazardous waste facilities. This explanation posits the idea that the political influence of individuals (i.e., power and access to the decision-making process) explains why some receive benefits and some do not (Pastor 2003; Saha and Mohai 2005). In other words, because impoverished and minority populations tend to have limited resources for taking political actions, their voices fail to register. Furthermore, immigrants lacking U.S. citizenship tend to compose a vulnerable population segment excluded from governmental benefits because they do not yet exert any political influences such as found in voting. Bullard (2000) claims, for example, that siting of hazardous waste facilities tends to follow the "path of least political resistance" which holds that siting permits for hazardous waste facilities are often issued in areas populated by less politically powerful groups. Bullard and Wright (1987) claim that a promise of employment opportunities and a broadened tax base in economically distressed area often justifies siting of hazardous waste facilities in impoverished and minority neighborhoods. That is, because residents in economically distressed areas desperately need employment opportunities, environmental risks and potential adverse health effects due to siting of hazardous waste facilities are often seen as acceptable tradeoffs. In other words, residents in economically distressed areas are forced to make personal sacrifices for employment opportunities, or termed as environmental blackmail (Bullard and Wright 1987: 23).

Pastor (2003) reviews the siting disparities of TSDF studies in the Los Angeles area and concludes that they support a political rationale. Cole and Foster (2001) also claim that minority voices are not heeded in siting decisions. More direct evidence with respect to sociopolitical theory can be found in a study examining relationships between capacity expansion of hazardous waste facilities and racial and socioeconomic conditions

of zip codes where the facilities were sited (Hamilton 1995). This study finds that percent of persons voting in the county[1] is the strongest predictor while percent of minority in zip codes is not a statistically significant predictor of whether hazardous waste facilities expand their capacity when voting is controlled. Considering voting as proxy to political power, this study supports the sociopolitical theory. Cole and Foster (2001) observe that building a coalition to form stronger political power is often proven to be effective. In the Chester, Pennsylvania, case where governments granted placement of commercial waste facilities in the African American enclave, residents of this community filed a lawsuit. When they failed to dissuade governments from placing a waste facility, coalitions between Chester Residents Concerned about Quality of Life (CRCQL) and external organizations such as Campus Coalition Concerning Chester was formed. Known as C4, such a coalition delivered a strong message to local governments and corporations, and settlements between companies and residents were reached. These two examples stress the important of political power to obtain governmental concessions. In short, the central thesis of the sociopolitical theory lies in the assertion that politically powerless groups in being excluded from the benefits from governmental decisions often suffer disproportional burdens.

In collective actions or social protests to acquire governmental concessions, resource mobilization theorists claim that resource availability is one of the key factors (McCarthy and Zald 1997; Morris 1981). In other words, political clout is to some extent a function of the availability of resources to individuals and groups for mobilizing a community into action. Resources cannot be narrowly defined in monetary terms but in more inclusive terms such as the presence of pre-existing organizations or pre-established networks (Schwartz and Paul 1992). Schwartz and Paul (1992), for example, argue that the possession of monetary resources alone does not lead to successful social movements. They show that the organization Mother Against Drunk Driving (MADD) received great support among the general public, and large public supports were realized (congressmen, media, and money). However, in terms of membership this movement failed to generate the membership increases comparable to other social movements such as Southern Farmers' Alliance and National Organization for Women. Pre-existing

[1] Although unit of analysis in this study is zip codes, the author estimates the voting by percent of county.

social networks and organizations emerged from the Civil Rights Movement to contribute to the emergence of the environmental justice movement (Taylor 2000).

Although resource mobilization theorists conceive of resources in a broader sense, socioeconomic status is important because those who have financial, informational, and other resources are more likely to mobilize and have influence. That is, higher socioeconomic wealthy individuals tend to create social networks (or social cliques) to help each other. Through established social networks, they mutually support each other (Mill 1994). Thus, socioeconomic status can serve as proxy to current and future resource availability. Given the importance of financial, informational, and other resources, socioeconomic conditions of neighborhood can be predictors of which neighborhoods are prioritized for brownfield cleanup and which ones are not.

Finally, Saha and Mohai (2005) argue that indirect institutionalized discrimination is another possible explanation of why siting disparities of hazardous waste facilities exist. Indirect institutionalized discrimination "refers to practices having a negative and differential impact on minorities and women even though the organizationally prescribed or community-prescribed norms or regulations guiding those actions were established, and are carried out, without prejudice or intent to harm laying immediately behind them" (Feagin and Feagin 1987: 31). That is, the discriminatory intent of certain actions is irrelevant to determining indirect institutional discrimination. Rather, the discriminatory outcomes or consequences are crucial to the concept of indirect institutional discrimination. Feagin and Feagin (1987) explain two forms of indirect institutionalized discrimination: side-effect and past-in-present discrimination. Side-effect discrimination refers to discriminatory consequences in one area resulting from discrimination in other areas; discrimination in education, for example, leads to unequal economic opportunities in employment. Past-in-present discrimination refers to discriminatory consequences in the present resulting from intentional denial from the past; discrimination in hiring practices in the past, for instance, results in unequal job seniority in the present between minorities and whites.

Indirect institutionalized discrimination is applicable to possible discriminatory cleanup prioritization. Due to past constraints (prior to the 1960s) of political activities against minorities such as voting, minorities are underrepresented in the political arena,

which leads to the fact that voices of minorities are not often seriously heard. Although this version of indirect institutionalized discrimination seems to be embedded in the sociopolitical process[2], many additional racially discriminatory practices (i.e., residential segregation and labor market discrimination) existed in the past, which leads to contemporary racial inequalities.

Although the theoretical dimensions described above (the sociopolitical theory, resource mobilization, and indirect institutionalized discrimination) might seem to be independent of each other, such dimensions are inter-related. Past-discrimination has denied economic and social opportunities of minority populations, leading to resource and network deficiency. Such deficiency leads to lack of political power of minority populations. Resource availability is also a key in establishing strong political power. Thus, such a complicated structural racial inequality makes minority populations be vulnerable to environmental burdens.

4-3 Research Hypotheses

Research question 1 asks whether brownfields are disproportionately located near impoverished and poor neighborhoods. In addition, research question 2 asks whether the presence of brownfields is associated with decline in socioeconomic conditions of adjacent neighborhoods. In order to answer those questions, hypotheses are developed by relying on spatial concentration of poverty (selective out-migration and residential segregation).

Hypothesis 1. Given selective out-migration and historical residential segregation, brownfields are disproportionately located near impoverished and minority neighborhoods. Although brownfield development was initiated in the mid-1990s, its economic effect might be too early to be realized. This hypothesis will be tested by virtue of the associations between the locations of brownfields and the racial socioeconomic conditions of adjacent neighborhoods by using the 2000 US Census.

[2] Zimmerman (1993) finds that when National Priority List (NPL) sites became controversial near white neighborhoods, residents of such neighborhoods enjoy prompt cleanup of NPL sites. However, controversial NPL sites in African American neighborhoods, such sites will not be cleaned up promptly. Furthermore, the Warren county incident, where the government proposed a toxic incinerator in a poor and African American community, serves as another example. Even though residents of Warren County successfully promoted their cases in the national level and enjoyed supports from the whole nation, residents and their allies failed to accomplish the main goal (dissuading hosting the toxic incinerator: Labalme 1989). These two examples suggest that minority populations might have fundamentally limited political powers compared to whites due to past discrimination.

Thus, if brownfields are more likely to be located near impoverished neighborhoods with high concentrations of minorities, this hypothesis is then supported.

Hypothesis 2. Because deindustrialization resulted in rather than resulted from socioeconomic decline of inner city neighborhoods, the presence of category 1 brownfields is associated with socioeconomic decline of neighborhoods adjacent to category 1 brownfields after, not before, 1970. Furthermore, given concentration of poverty, neighborhoods adjacent to category 2 brownfields experience a decline in their socioeconomic conditions after 1970. It would be a good idea if the brownfield sample in this study could be categorized into the two groups to probe the causal relationships between locations of brownfields and socioeconomic decline in adjacent neighborhoods. However, there is insufficient information to categorize brownfields into the two groups. Due to such limitation[3], this hypothesis tests whether there are associations, rather than causal relationships, between locations of brownfields and socioeconomic decline in adjacent neighborhoods.

This hypothesis will be tested based on longitudinal assessment of socioeconomic changes between neighborhoods adjacent and far from brownfields from 1960 to 2000. Thus, if neighborhoods with the presence of brownfields within certain radii (0.5 mile radius or 1.0 mile radius) experience a more dramatic decline in socioeconomic conditions after 1970 than the decline before 1970, this hypothesis is then supported. Furthermore, if neighborhoods with the presence of brownfields within certain radii experience a more dramatic decline in socioeconomic conditions than do neighborhoods with no brownfields within certain radii, this hypothesis is also supported.

Hypothesis 3. Given selective out-migration and contemporary residential segregation, middle class African Americans relocated from neighborhoods adjacent to brownfields; however, they did not move any appreciable distance from neighborhoods adjacent to brownfields. This hypothesis will be tested based on changes in coefficient values of racial and economic variables between 0.5, 1.0, and 1.5 mile radii from brownfields with employment of multivariate regression. If coefficients of racial

[3] Regardless of data limitation, brownfields tend to be spatially concentrated. Because the creation of category 1 brownfields affected socioeconomic conditions of adjacent neighborhoods where category 2 brownfields tended to be subsequently located, it can be assumed a close proximity between category 1 and 2 brownfields.

variables increase yet ones of economic variables (i.e., income) decrease their explanatory powers as radius from brownfield expanded (from 0.5 mile to 1.5 mile), this hypothesis is then supported.

Research question 3 asks which neighborhoods enjoy brownfield cleanup prioritization. In order to answer this question, hypotheses are developed by relying on resource mobilization theory, sociopolitical theory, and indirect institutionalized discrimination.

Hypothesis 4. Because sociopolitical theory stresses the importance of political power to receive benefits from governmental policies, cleanup prioritization of brownfields is given to neighborhoods having stronger political power. It appears that resource is a key to establish strong political power, which suggests that individuals with higher socioeconomic conditions have a greater political power than do ones with lower socioeconomic conditions. This hypothesis thus will be tested based on associations between socioeconomic characteristics of neighborhoods and cleanup prioritization of nearby brownfields. That is, if neighborhoods that have higher socioeconomic characteristics are more likely to get prompt cleanup of nearby brownfields than are neighborhoods that have lower socioeconomic characteristics, this hypothesis is then supported.

Hypothesis 5. Because indirect institutionalized discrimination explanations focus on disproportional consequences based on race regardless of intent, cleanup prioritization is predicted to be given to neighborhoods having lower concentrations of minorities. This hypothesis will be tested based on associations between cleanup prioritization and racial composition of adjacent neighborhoods. Thus, if brownfields near neighborhoods with high concentrations of minorities are not likely to get cleanup prioritization, this hypothesis is then supported. Moreover, if race remains a significant predictor of cleanup prioritization even after socioeconomic and sociopolitical characteristics are controlled, such a finding suggests that direct institutionalized discrimination might exist in brownfield cleanup prioritization. Direct institutionalized discrimination[4] refers to

[4] Feagin and Feagin (1986: 30) discuss direct institutionalized discrimination as "organizationally-prescribed or community-prescribed actions which have an intentionally differential and negative impact on members of subordinate groups. Typically these actions are not carried out on an episodic or sporadic basis, but continually or routinely by a large number of individuals guided by the rules of a large-scale

the fact that statistically racial variables maintain explanatory power that socioeconomic and sociopolitical variables cannot explain. However, this does not provide evidence of the existence of intentional racial bias because it can be possible that variables that are not introduced in the regression model can explain cleanup prioritization mediating through racial variables. However, before finding those variables, direct institutionalized discrimination is partially responsible for disparate cleanup prioritization. The next chapter will discuss methods of this dissertation including data, variables, and spatial as well as analytic methods.

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organization."

Table 4-1 Manufacturing employment in Detroit from 1947 to 1977

	1947	1954	1958	1963	1967	1972	1977
Manufacturing Firms	3372	3453	3363	3370	2947	2398	1954
Total Manufacturing Employment (1000)	338.4	296.5	204.4	200.6	209.7	180.4	153.3
Total Production Employment (1000)	281.5	232.3	145.1	141.4	149.6	125.8	107.5

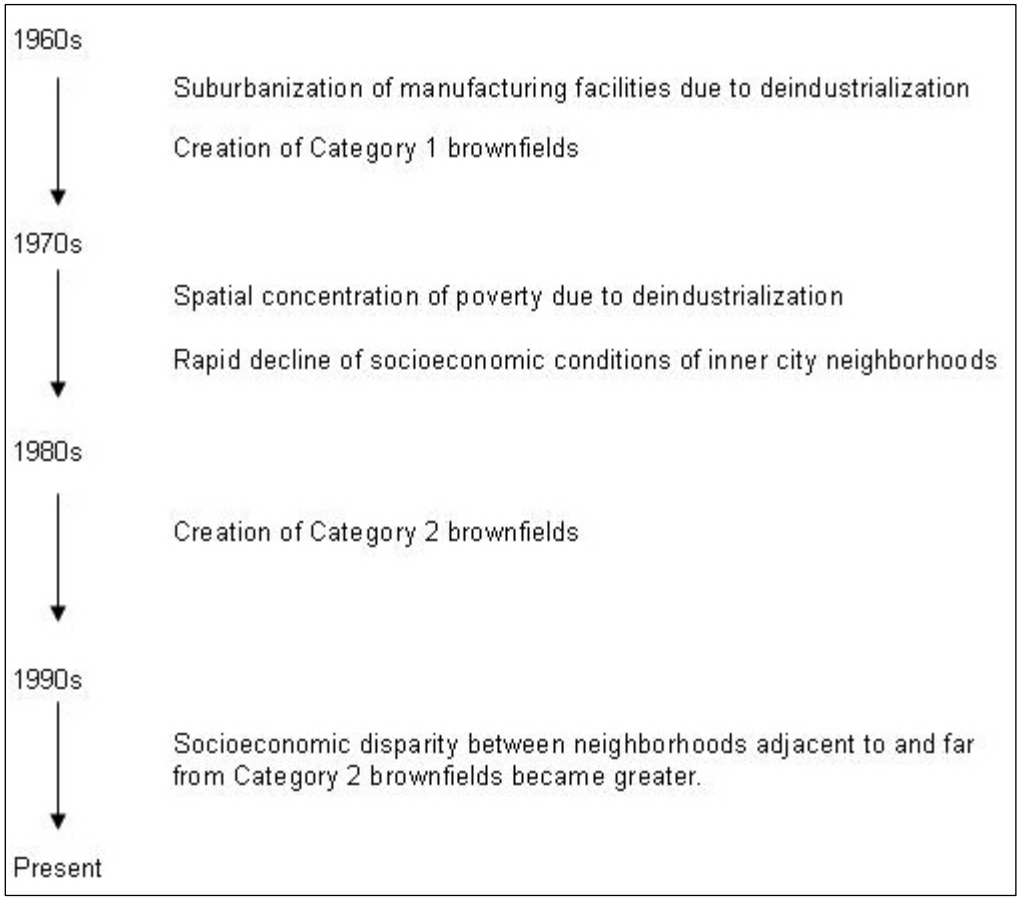
(Sugrue 1996: 144)

Table 4-2 Numbers of manufacturing establishments and their employees in the tri-county area from 1947 to 1992

	1947	1963	1972	1982	1992
Numbers of Manufacturing Establishments					
City of Detroit	3272	3370	2398	1518	1061
Suburbs (Macomb, Oakland, and Wayne)	1493	3653	4726	5763	6195
Total	4765	7023	7124	7281	7256
Total Employees in Manufacturing (in 1000)					
City of Detroit	338	201	180	106	62
Suburbs (Macomb, Oakland, and Wayne)	219	294	356	302	339
Total	557	495	536	408	401

(Farley et al. 2000: 66)

Figure 4-1 Chronology of orders of events and their consequences



CHAPTER 5: RESEARCH METHOD

As previously discussed, three research questions and five hypotheses constitute this dissertation. The first research question asks whether brownfields are disproportionately located near impoverished and minority neighborhoods, the second whether the presence of brownfields is associated with the socioeconomic decline of adjacent neighborhoods, and the third whether brownfield cleanup prioritization is associated with the racial and socioeconomic conditions of nearby neighborhoods. To address those three questions, this chapter discusses the data and spatial/analytic methods of the dissertation.

The study area of the dissertation is the tri-county area including Macomb, Oakland, and Wayne counties within the Detroit Primary Metropolitan Statistical Area (PMSA) comprised of the six counties of Lapeer, Macomb, Monroe, Oakland, St. Clair, and Wayne per definition by the 2000 Census of Housing and Population (see Figure 5-1). This study proposes to conduct a secondary data analysis use of demographic and spatial data referring to locations of brownfields provided by the Michigan Department of Environmental Quality (MDEQ) and demographic data referring to racial and socioeconomic characteristics from the 1960, 1970, 1980, 1990, and 2000 US Census of Housing and Population. While cross-sectional analyses are used to answer the first and third research questions[1], longitudinal analyses of data from 1960-2000 US Census of Housing and Population are used to answer the second research question. The unit of analysis for research questions 1 and 3 is the census block group, while the census tract is the unit of analysis for research question 2. Because census block groups are the smallest available census units containing racial and socioeconomic characteristics, they are selected as the unit of analysis when applicable. In conducting longitudinal analyses, however, employment of census block groups is not feasible because census block groups

[1] The racial and socioeconomic characteristics of census block groups were extracted from the 2000 US Census of Housing and Population in answer to the first research question, whereas the above characteristics were extracted from the 1990 US Census of Housing and Population in answer to the third research question.

did not exist in 1960 and 1970. As an alternative, census tracts are used in conducting longitudinal analyses.

5-1 Data

5-1-1 Spatial Data

With reference to chapter 1 in which two formal definitions of brownfields are provided, the United States Environmental Protection Agency (USEPA) Region 5 defines brownfields as "abandoned, idled, or underutilized industrial or commercial sites where expansion or redevelopment is complicated by real or perceived environmental contamination that can add cost, time, or uncertainty to a redevelopment project" (Davis 2002: 5). On the other hand, the United States Office of Technology Assessment (USOTA) defines brownfields as sites "whose redevelopment may be hindered not only by potential contamination, but also by poor locations, old, or obsolete infrastructure, or other less tangible factors often linked to neighborhood decline" (Davis 2002: 5). No formal definition of brownfields is found in the Brownfield Redevelopment Financing Act; however, in the definition section of this Act, a definition of 'blighted properties' is provided, suggesting that the state of Michigan accepts the brownfield definition provided by the United States Office of Technology Assessment which includes physically deteriorated structures not suspected of having environmental contamination in the form of brownfields.

The state of Michigan provides no complete lists of brownfields. When the web-site of the Michigan Department of Environmental Quality is searched using 'brownfield' as the key word, only Underground Storage Tank (USTfield) and Leaking Underground Storage Tank (LUST) lists are found. Properties are listed in the LUST database if environmental contamination (from underground storage tanks) has occurred and the property is still in use. The USTfield database, on the other hand, includes only abandoned properties with past releases from underground storage tanks (e.g., gas stations, dry cleaners, body shops). The USTfield database is a conglomeration of several databases created from lists of state-funded cleanup sites. Furthermore, the Baseline Environmental Assessment (BEA) indicates that additional sites not on the LUST list (i.e., abandoned gas stations whose underground tanks has been removed) are included in the USTfield database (Smedley 2006a). These assessments of the extent of

contamination of properties can be performed if a local government identifies properties suspected to be environmentally contaminated. Prospective owners can also request local governments to perform BEAs to avoid future environmental liabilities from properties they are about to purchase (MDEQ undated). It can thus be assumed that all brownfields listed in the USTfield databases are in fact brownfields, though those databases do not cover all brownfields in the study area. Unfortunately, large-scale abandoned industrial sites, or category 1 brownfields, are not included in this database. No database for such sites, to the best of author's knowledge, exists.

The theoretical framework in this dissertation is built around explaining the socioeconomic impacts of abandoned or underutilized properties in adjacent neighborhoods. In other words, a key hypothesis will be that properties are abandoned or underutilized because employment opportunities have disappeared. As explained previously, LUST sites include currently active properties that contain leaking underground tanks, while the USTfield database consists of abandoned properties with old releases that have not been cleaned up. Because LUST sites include many environmentally contaminated properties when they are still in active use, it is difficult to attribute socioeconomic decline to the presence of such sites (such as the linkage between disappearance of jobs and concentration of poverty) (see chapter 4 for detailed discussion). In addition, LUST database does not contain the cleanup status information that is essential for addressing the third research question of which neighborhoods enjoy prompt cleanup. For those reasons, LUST sites are not appropriate candidates for brownfields and thus are excluded from this study. Because there is no other brownfield databases except for LUST and USTfield, identification of brownfields in this dissertation is thus based on the USTfield database provided by the Michigan Department of Environmental Quality (MDEQ)[2].

Admittedly, the USTfield database is an incomplete list of brownfields (Smedley 2006a), and the MDEQ is currently working on developing a more complete list of

[2] This information is available through the web-page (http://www.deq.state.mi.us/ustfields). The list of brownfield properties in this web-page were completed in May 2004. The MDEQ assesses whether those sites are environmentally contaminated. If contaminated, they are cleaned up and redeveloped; otherwise, they are redeveloped.

brownfields[3]. This is an ambitious project, however, and an updated list is not available nor has a release date been announced. As previously discussed, there are three reasons that make it difficult to assess the exact number of brownfields applicable to this study: (1) local governments are reluctant to admit that they have many brownfields given brownfield association with stigma (Greenberg et al. 2000), (2) property owners do not report their abandoned properties for fear of incurring expensive cleanup costs (mothballed properties; Greenberg et al. 2000), and (3) the MDEQ has failed to track blighted or functionally obsolete properties for environmental contamination resulting from other than underground tanks (Smedley 2006a). Considering the difficulty of assessing the exact number of brownfields in Michigan, the MDEQ's USTfield database stands as the most complete list of brownfields available in the study area. To this author's best knowledge, no prior study has taken advantage of this database as a proxy to brownfields.

There are 389 brownfields listed in the USTfield database in the study area. The UTSfield database does not provide zip codes for properties, which are necessary for geo-coding. Zip codes for the brownfields were thus obtained from Mapquest, a firm that provides maps that include zip codes when street addresses, cities, and states are given. The address of each brownfield in this database was thus manually entered and the appropriate zip codes extracted. In extracting the zip codes of the properties, those of 34 properties (8.7%) were not to be found, either because of incorrect street names or incorrect city or municipality names. By excluding those zip codeless properties, the number of brownfields included in this study was thus reduced to 355. Figure 5-2 shows the general pattern of brownfield locations, which tends to be concentrated in the city of Detroit and adjacent cities and townships.

Finally, the USTfield database provides the cleanup statuses of listed brownfields, which are (1) 'not cleaned up,' (2) 'completed,' (3) 'in progress,' (4) 'pending,' (5) 'cancelled,' (6) 'closed,' and (7) 'time to be assigned' (see Table 4-1 for detailed information on these statuses). The three statuses of 'not cleaned up,' 'completed,' and 'in progress,' are straightforward while others need further explanations. 'Pending'

[3] This list includes sites in USTfield data as well as properties submitted for approval under the Brownfield Redevelopment Financing Act (Act 381 of 1996) for school tax capture to reimburse eligible environmental costs.

means that environmental assessments or cleanups are temporarily ceased due to insufficient funds. 'Closed' refers to the completion of environmental assessments with the determination of no serious environmental contamination requiring cleanup actions, while 'cancelled' refers to the completion of an environmental assessment with no environmental contamination. Although both the 'closed' and 'cancelled' statuses do not require cleanup actions, environmental contamination short of being serious enough to warrant action is found in the 'closed' status, while no environmental contamination was found in the 'cancelled' status. 'Time to be assigned' status means that cleanup actions will be made later and have equivalence to 'not cleaned up' (Smedley 2005).

5-1-2 Census Data

The 1970-2000 census data comes from Geolytic, Inc., and provides not only the racial and socioeconomic characteristics of census units (i.e., census tracts and census block groups) but also digitized maps of census units. There are three sources of data for racial and socioeconomic characteristics. To address the first research question of whether brownfields are disproportionately located in impoverished and minority neighborhoods, the racial and socioeconomic characteristics of census block groups in 2000 were obtained from the 2000 Geolytic Census of Housing and Population. Furthermore, in addressing the third research question of whether brownfield cleanup prioritization is associated with socioeconomic conditions of nearby neighborhoods, racial and socioeconomic characteristics of census block groups in 1990 were also taken from the 1990 Geolytic Census of Housing and Population. Because the second research question of whether the presence of brownfields is associated with decline of socioeconomic conditions of adjacent neighborhoods involves longitudinal data analysis, racial and socioeconomic characteristics are extracted from Geolytic's Neighborhood Change Database (NCDB) that normalized census tract boundaries in 1970, 1980, and 1990 to the boundaries in 2000[4]. Use of NCDB reveals that normalized census tract boundaries from 1970 to 2000 are consistent, a fact that enables researchers to conduct

[4] Geolytics Inc., teamed up with the Urban Institute to create proprietary weighting tables for 1970, 1980, and 1990 for use in converting census tracts from previous years into census tracts of 2000 (Tatian, 2003). The proprietary weighting tables were created on the basis of the populations of the blocks of preceding years. By summing up and weighting the population of census blocks in preceding years (i.e., 1970, 1980, and 1990) which geographically correspond to the tract boundaries of 2000, both Geolytics Inc. and the Urban Institute claim that this method ensures more accurate data estimation than reliance on the simple areal apportionment method (Geolytics Inc. undated; Tatian, 2003).

longitudinal analyses. Because Geolytic, Inc., does not provide 1960 census data on the tract level, the racial and socioeconomic characteristics for all census tracts in the tri-county area had to be manually extracted from the 1960 US Census of Housing and Population. These data were thus obtained from the University of Michigan Map Library which has the 1960 digitized census tract boundaries for the tri-county area. Inconsistent census tract boundaries from 1960 onward were addressed with by employing distance-based methods to be discussed later in this chapter.

5-1-3 Variables

There are four groups of independent variables in this dissertation: racial, socioeconomic, sociopolitical, and housing, and these variables are frequently used in environmental justice and urban sociology studies. Although two different units of analysis (census block groups for the first and third research questions and census tracts for the second research question) are used, the same variables are applied. Racial variables include percents of non-Hispanic white persons[5], African Americans, and Hispanics. Socioeconomic variables include percents of female-headed families with dependent children, persons below the poverty line, households receiving public assistance, unemployed persons, average household income[6], and average housing values for owner-occupied housing units. Sociopolitical variables include percents of persons over 25 who do not have a high school diploma, persons over 25 who have a bachelor's degree or higher, employed persons occupied in white collar occupations[7], and employed persons occupied in blue collar occupations[8]. Housing variables include percents of vacant housing units and owner-occupied housing units.

Because various racial and socioeconomic variables are not available in 1960, racial and socioeconomic variables for the first part of the second research question are based on what variables are available in the 1960 Census. Racial and socioeconomic variables not available in 1960 but became available in the later decades are (1) the percent of non-

[5] For the longitudinal analyses, the percent of whites is used because the number of non-Hispanic whites did not exist in 1960 and 1970 US Census data.
[6] For the longitudinal analyses, average family income is used because it did not exist in the 1960, 1970, and 1980 US Census data.
[7] White collar occupations include the professional and managerial.
[8] Blue collar occupations include the construction, production, transportation, and material-moving.

Hispanic whites[9] (2) the percent of Hispanics, (3) the percent of female-headed family with dependent children, (4) the percent of persons under the poverty line, (5) the percent of household receiving public assistance income, and (6) average household income[10]. Occupational variables such as percent of blue and white collar occupations are not included. Because major categories of occupational variable in the 1960 census report were not comparable to later decades, all sub-categories of such a variable need to make comparable white and blue collar occupations. Manually extracting all sub-categories of such a variable for the census tract level turns out to be labor and time intense. Due to limited personal and financial resources, occupational variables are excluded. For more detailed information with respect to the construction of these variables, see Appendices A, B, C, and D.

Each research question employs slightly different sets of dependent variables. For example, dependent variables for the first research question are the presence of brownfields within certain radii (0.5, 1.0, and 1.5 miles) from brownfields and numbers of brownfields within 0.5, 1.0, or 1.5 mile radius from block group centroids. However, the dependent variable for the third research question is the percent of cleaned-up brownfields within certain radii (0.5 and 1.0 mile) from block group centroids. For the second research question, the dependent variable is whether the majority of the areas in census tracts are captured by 0.5 or 1.0 mile circular buffers from brownfields. Each dependent variable will be discussed in greater detail in the corresponding results chapters.

5-2 Method

5-2-1 Spatial Method

Brownfields were geo-coded by employing the address-matching function in ArcView 3.3. In using address-matching to place a point on a digitized map, street maps with street addresses, cities, and zip codes are required. The Topologically Integrated Geographic Encoding and Referencing file (TIGER: available at Census Bureau web site: http://www.census.gov/geo/www/tiger) contains not only an all-streets network but also census units such as census tracts, census block groups, and census blocks for every

[9] This variable is replaced by the percent of whites.
[10] This variable is replaced by the average family income.

county in the United States. Thus, the 2000 TIGER file was employed for address-matching in placing brownfields on digitized maps containing the census units in the tri-county area.

This dissertation employs distance-based methods (or the aggregating or averaging of spatial units in accordance with distance from points of interest) to define the neighborhoods nearest brownfields. Three methods (the centroid-containment, the 50% areal containment, and the areal apportionment) were employed given inconsistent census boundaries between decades and the author's convenience, which is to be discussed below. The centroid containment method aggregates or averages the socioeconomic characteristics of census units whose centroids are captured within circles of a specified distance from brownfields. The 50% areal containment method aggregates or averages the socioeconomic characteristics of census units in which more than 50% of their areas are captured within circles of a specified distance from brownfields. The areal apportionment method aggregates the weighted population characteristics of the census units intersected by the circles of a given radius, with weights equaling the proportion of areas of the census units falling within the radius of a facility (Mohai and Saha 2006). For example, if a census tract has a population of 1000 and 30% of its area falls within the radius of a facility, the number of individuals potentially under the influence of that facility can be estimated to be 300 (1,000*0.3). If 50% of the area of another tract falls within the same radius, then 50% of its population is taken and combined with that of the first, and so on. The areal apportionment method assumes that populations are uniformly distributed in spatial units, though this is not always true; nonetheless, this method is capable of more precisely capturing population near sites than the conventional unit-hazard coincidence method (see Mohai and Saha 2006, 2007). Because there is to date no scientific evaluation to measure the precise socioeconomic impacts of brownfields to adjacent neighborhoods, several distances (0.5, 1.0, 1.5, and 2.0 mile) were employed to compare results from among them. This comparison can then determine whether the use of different distances from brownfields seriously alters the results.

This study employs all the distance-based methods for various reasons. First, the areal apportionment method is used for descriptive statistics. This method tends to yield

more consistent results than the other two methods regardless of which spatial units (zip codes, census tracts, census block groups) are used (Mohai and Saha 2007). However, statistical tests under the areal apportionment method are difficult to conduct. Thus, the centroid containment and 50% containment methods were used when conducting statistical tests. In addition, the areal apportionment method was used in conducting longitudinal analysis employing 1960-2000 US Census data, because the 1960 census tract boundaries are inconsistent with the boundaries from subsequent decades and areal apportionment defines circular buffers around brownfields that prove most consistent and stable from decade to decade.

In the statistical analyses, the centroid containment method is used when the unit of analysis was census block groups. If the unit of analysis is census tracts, the 50% areal containment method is used. Ideally, a consistent approach would be used in applying the distance-based method. However, when computing the number of brownfields captured within 0.5, 1.0, or 1.5 mile radii from block group centroids, the process that uses the 50% areal containment method turns out to be labor and time intensive[11]. Furthermore, when the unit of analysis is the block group, both the 50% areal containment and centroid containment methods capture the identical census block groups within 0.5 and 1.0 mile radii from brownfields. For this reason, the centroid containment method is used when block groups are used in the analyses.

When the unit of analysis is the census tracts, however, the two distance-based methods capture different sets of tracts. For example, centroids of thirteen census tracts in the 1960 US Census are captured within a 1.0 mile radius from brownfields, yet less than 50% of the areas for these census tracts are captured within a 1.0 mile radius from brownfields (see Figure 5-3 (a)) Conversely, eight census tracts are captured by 1.0 mile circular buffers from brownfields at least 50% of the areas, but the centroids of these census tracts are not captured within a 1.0 mile circular buffers from brownfields (see Figure 5-3 (b)). When the socioeconomic impacts of brownfields are estimated, it

[11] Arcview software provides the direct function of selecting spatial units (i.e., census block groups) if their centroids fall into the other geographical feature (i.e., into the circular buffer from brownfields). When the 50% areal containment method is used, several steps must be manually taken to compute the proportion of census units captured by circular buffers from block group centroids. Because the number of brownfields must be computed by one brownfield at a time (N=355), use of the 50% areal containment method adds thousands of additional steps in comparison to the centroid containment method.

makes more sense to the attribute the presence of brownfields to socioeconomic conditions of census tracts in which the majority areas of census tracts have fallen into circular buffers from brownfields rather than in which centroids have simply fallen into the buffers. For this reason, the 50% areal containment method is used when the unit of analysis is census tracts.

Conventionally, the unit-hazard coincidence method, or simple dichotomization of spatial units in accordance with the hosting or non-hosting of at least one hazard of interest, has been widely employed in environmental justice research (Mohai and Saha 2006). The problem with this method lies in its inability to capture nearby spatial units that might be affected by the hazard of interest (i.e., hazardous waste facilities or brownfields). This method is particularly problematic for proposed of this study because it uses census units in urbanized areas where such units tend to be small (Mohai and Saha 2006). Thus, nearby units may also be located quite close to brownfields. For instance in Figure 5-4 (a), only one census block group is captured by the unit-hazard coincidence method (see the darkly shaded block group containing the site). However, four additional census block groups relatively close to the brownfield site are captured by the centroid containment method using a 0.5 mile radius from the brownfield site. If the radius is expanded from 0.5 mile to 1.0 mile, several additional census blocks are captured (see Figure 5-4 (b)). If the unit-hazard coincidence method is used, many census block groups that could be influenced by a site are excluded, which could lead to critical measurement errors. For this reason distance-based methods are used in this dissertation.

Ideally, brownfields should be categorized into two groups: category 1 brownfields, or large manufacturing facilities and category 2 brownfields, or small-scale neighborhood service facilities (see chapter 4 for detailed discussion). Based on names of brownfields in the USTfield database, 251 brownfields appear to be category 2[12]. The remaining 104 brownfields, it is difficult to determine which category (category 1 or category 2) they fall. Although given that the brownfields in USTfield database contain underground storage tanks which are frequently found in service-oriented facilities such

[12] If the name of brownfield is 'shell gas station,' then this brownfield is category 2. Other typical names that help categorize brownfields are 'body shop' or 'dry cleaner.'

as gas statsions, it appears that brownfields in this database might be category 2, insufficient information is provided in the USTfield database to make a definitive categorization of brownfields. In addition, it is essential to know the dates when properties were abandoned and these data are unavailable. Such information can potentially be obtained via an examination of parcel records for each property. However, many property owners continue to pay property taxes even after they decide to stop using their properties out of fear of possible expensive cleanup costs. Thus, the dates of discontinued payments of property taxes from parcel records are not an accurate determiner of property abandonment. Because of these limitations, longitudinal analyses in this dissertation attempts to establish associations at best between the presence of brownfields and the socioeconomic conditions of adjacent neighborhoods rather than establish causal relationships between the two.

Finally, brownfields are spatially concentrated such that it is difficult to classify block groups by brownfield cleanup prioritizations through use of the seven statuses provided by the USTfield database. That is, one 1990 census block could be located within several brownfields whose cleanup statuses differ. This is problematic given that observations must be independent of each other in the conducting of statistical analyses. To ensure that observations are independent of each other, cleanup statuses are dichotomized into two categories, after which the percentages in each category over the total number of brownfields were computed. The first category signifies that cleanup actions have not been initiated. Thus the two statuses ‘not cleaned up’ and ‘time to be assigned’ were combined. The second category signifies that cleanup actions have been initiated or completed. At this point the remaining five statuses were combined. For example, suppose that there are five brownfields within a 1.0 radius from a centroid of a census block group and cleanup status for two of the five brownfields is ‘completed,’ the cleanup status for the third is ‘cancelled,’ and the cleanup status for the remaining two is ‘time to be assigned.’ The value assigned to this census block group is therefore 0.6 (three out of five), meaning that cleanup actions has been initiated for 60% of brownfields within a 1.0 mile radius from a centroid of this census block.

5-2-2 Analytic Method

Several analytic methods are employed in this dissertation. For the first and third

research questions, cross-sectional analyses are performed. Both descriptive statistics involving bi-variate correlations and multi-variate analyses involving logistic and linear regressions are applied. For the first research question of whether brownfields are disproportionately located near impoverished and minority census block groups, the dependent variable for the logistic regression is whether the centroids of census block groups are located within a 0.5 or 1.0 mile radius from brownfields. On the other hand, the dependent variable for the linear regression is the number of brownfields located within a 0.5 or 1.0 mile radius from block group centroids. For the third research question of whether or not the cleanup prioritization of brownfields is associated with racial and socioeconomic conditions of nearby census block groups, the dependent variable for the linear regression is the percent of brownfields within a 0.5 or 1.0 mile radius from block group centroids in which cleanup actions have been initiated. Racial, socioeconomic, sociopolitical, and housing variables are used in terms of independent variables (see section 5-1-3 for the list of variables in the four categories).

For the second research question, longitudinal analysis is performed. The analytic method of this research question consists of two parts, the first part comparing the racial and socioeconomic conditions of census tracts or areas within and beyond a 1.0 mile radius from brownfields between 1960 and 2000and the second part comparing the racial and socioeconomic conditions of census tracts within and beyond 0.5 and 1.0 mile radii from brownfields between 1970 and 2000 as controlled for 1970 socioeconomic conditions. The first comparison examines socioeconomic changes in census tracts or areas within a 1.0 mile radius from brownfields between 1960 and 2000 and then compares them to socioeconomic changes in census tracts or areas beyond a 1.0 mile radius from brownfields in subsequent decades. Specifically, the first comparison determines whether the degree of decline in the socioeconomic conditions of census tracts or areas within a 1.0 mile radius from brownfields by decade is greater than the degree of decline in the socioeconomic conditions of census tracts or areas beyond a 1.0 mile radius from brownfields.

When statistical tests are employed, it is essential to have consistent spatial boundaries over time. In order to construct consistent spatial boundaries from 1960 to 2000, 1.0 mile circular buffers from each brownfield are created, and racial and

socioeconomic characteristics of each area are estimated by employing the areal apportionment method. To create a comparison group of non-host neighborhoods for the statistical analyses, the same numbers of random points are generated inside the study area and 1.0 mile circular buffers are drawn around them. Since there are 355 brownfields in this study, 355 random points are generated[13] (see Mohai and Saha 2007 for an earlier example of this approach). Then, racial and socioeconomic characteristics of areas within 1.0 mile radius from each random point (non-brownfield areas) are estimated by employing the areal apportionment method. The rationale in this approach is that if there is no relationship between the presence of brownfields and the decline in socioeconomic conditions near brownfields, difference in the socioeconomic characteristics of areas near brownfields will be similar to the difference in areas near random points between two time periods.

The second part of research question 2 addresses whether neighborhoods within a 0.5 or 1.0 mile radius from brownfields experienced greater socioeconomic decline between 1970 and 2000 than did neighborhoods beyond a 0.5 and 1.0 mile radius from brownfields when controlling for socioeconomic conditions of neighborhoods in 1970. Controlling for 1970 socioeconomic conditions means that neighborhoods sharing similar socioeconomic conditions in 1970 are categorized and changes in their socioeconomic conditions tracked separately. Therefore, the main research design for this analysis is the quasi-experimental research design that compares the racial and socioeconomic conditions between treatment and control groups in terms of treatment without random assignment (Robson 2002). The treatment group in this analysis refers to census tracts within a 0.5 or 1.0 mile radius from brownfields. The control group in this analysis refers to census tracts beyond a 0.5 or 1.0 mile radius from brownfields. In a true experimental design, random assignment of study subjects into the two groups (experimental and control) allows researchers to ensure that there are no pre-experimental differences between the two groups. That is, because subjects are randomly assigned into the two groups, it is assumed that such differences tend to be cancelled out between the two groups. Because of the random assignment, researchers are able to claim that observable post-experimental differences between the two groups can be attributed to the

[13] Random points were generated using ArcView 3.3.

treatment.

Unfortunately, it is impossible to randomly assign neighborhoods into brownfield and non-brownfield neighborhoods. Rather than relying on random assignment, the categorization of neighborhoods on the basis of socioeconomic characteristics in 1970 functions as a random assignment. In other words, controlling for the socioeconomic characteristics in 1970 minimizes the pre-existing socioeconomic differences between neighborhoods within and beyond a 0.5 or 1.0 mile radius from brownfields so as to establish more conclusive associations between the presence of brownfields and the decline in the socioeconomic conditions of nearby census tracts. Cluster analysis, the exploratory data analysis tool that sorts different objects into groups, is used to control for the socioeconomic conditions in 1970 (Aldenderfer and Blashfield 1984; Everitt et al. 2001; Kachigan 1991; Schneider and Roberts 2004; Sireci and Geisinger 1992). The main goal of cluster analysis lies in the development of clusters that "display small within-cluster variation, but large between-cluster variation" (Kachigan 1991: 262). Thus, if census tracts belong to the same cluster, they will share similar socioeconomic characteristics. Otherwise, the degree of associations is minimal among census tracts belonging to different clusters. Initially, each observation (in this study the census tract) stands as its own cluster, at which the two observations with the lowest distance or the highest association based on similar socioeconomic, sociopolitical, and housing characteristics are clustered together. This process then repeats until every observation is clustered and optimal clusters[14] have emerged (Aldenderfer and Blashfield 1984). The next chapter will present the results for the cross-sectional analysis of racial and socioeconomic conditions of neighborhoods adjacent to brownfields in 2000. This analysis aims at answering the first research question of whether brownfields are disproportionately located in impoverished and minority neighborhoods.

[14] Optimal clusters are achieved when the degree of associations becomes the least among census tracts belonging to same clusters.

Table 5-1 Cleanup Statuses in the USTfield Database

Category	Number	Percent	Explanation
‘not cleaned up’	148	41.7%	Cleanup actions have not been initiated.
‘time to be assigned	20	5.6%	Time of cleanup actions will be assigned later.
‘completed’	117	33.0%	Cleanup actions have been completed.
‘in progress’	36	10.1%	Cleanup actions have been in progress.
‘pending’	9	2.5%	Cleanup actions have been temporarily ceased due to insufficient funds
‘closed’	14	3.9%	Cleanup actions do not require because no contamination is found.
‘cancelled’	11	3.1%	Cleanup actions do not require because contamination is not serious enough.
Total	355	100.0%	

Figure 5-1 Tri-county area in the Detroit Primary Metropolitan Statistical Area

Figure 5-2 Locations of brownfields in the tri-county area

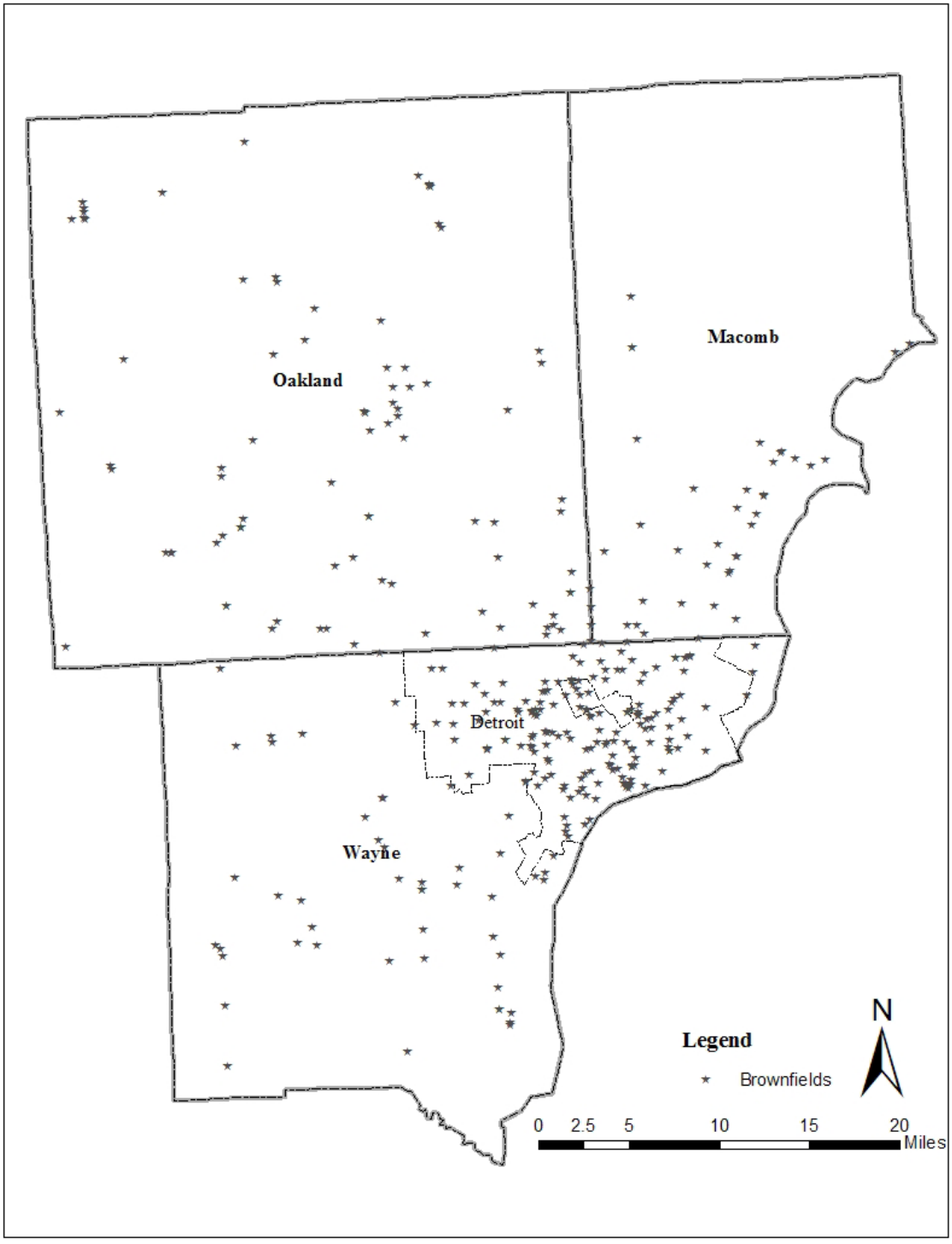
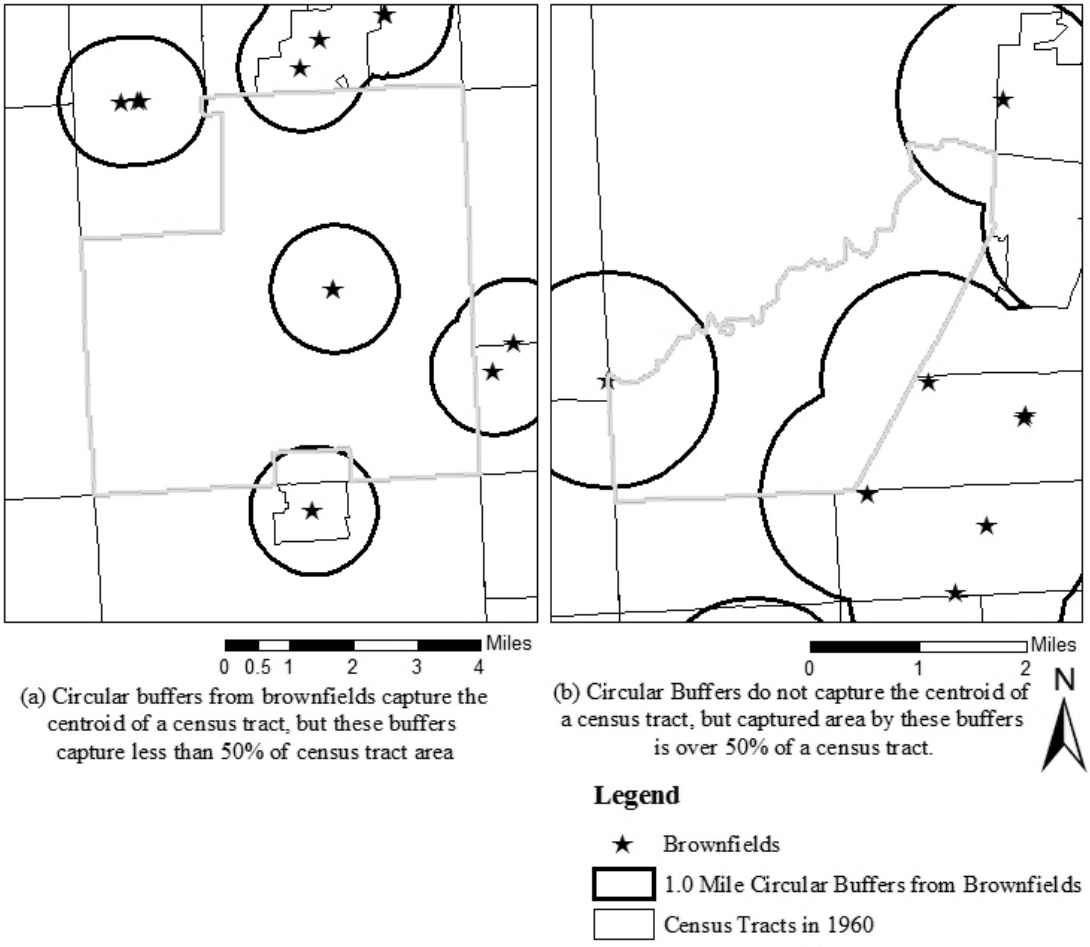


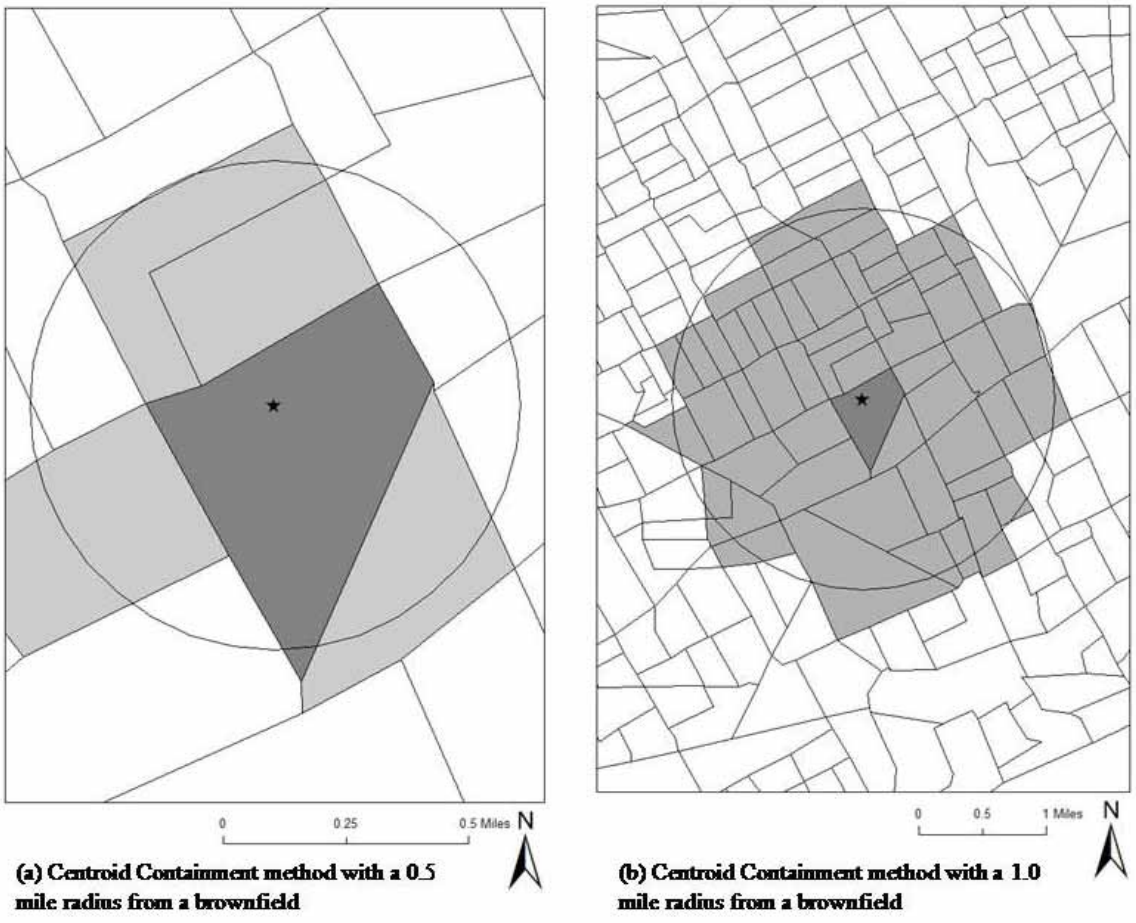
Figure 5-3 1960 Census tracts and 1.0 mile circular buffers from brownfields



(a) Circular buffers from brownfields capture the centroid of a census tract, but these buffers capture less than 50% of census tract area

(b) Circular Buffers do not capture the centroid of a census tract, but captured area by these buffers is over 50% of a census tract.

Figure 5-4 Census block groups captured by the unit-hazard coincidence method and the distance-based method



(a) Centroid Containment method with a 0.5 mile radius from a brownfield

(b) Centroid Containment method with a 1.0 mile radius from a brownfield

CHAPTER 6: CROSS-SECTIONAL ASSESSMENT OF RACIAL AND SOCIOECONOMIC CONDITIONS OF NEIGHBORHOODS ADJACENT TO BROWNFIELDS IN 2000

As discussed in the previous chapter, few studies either examine the racial and socioeconomic characteristics of neighborhoods adjacent to brownfields or develop the theoretical framework explaining why neighborhoods near brownfields are prone to socioeconomic disadvantage. An understanding of demographic characteristics is a prerequisite for local economic development plans because it can improve the effectiveness and efficiency of plans given that different population segments call for different policy remedies (Blakely and Bradshaw 2002). For the beginning step in brownfield research, this chapter examines the current locational disparity of brownfields. Specifically, this dissertation examines the socioeconomic conditions of neighborhoods near brownfields in the tri-county area in the Detroit region in 2000.

Environmental justice scholars have developed theoretical explanations as to why hazardous waste facilities are so often found in impoverished and minority neighborhoods (Mohai and Saha 2007; Saha and Mohai 2005). Although results might be similar – i.e., brownfields are disproportionately located in impoverished and minority neighborhoods – there are different theoretical explanations as to why brownfields are found in impoverished and minority neighborhoods. The important distinction between hazardous waste facilities and brownfields lies in whether the facilities are active or inactive. Because brownfields are often referred to as abandoned or underutilized properties, it is more critical to comprehend why properties are either abandoned or underutilized rather than why they are sited in those neighborhoods. Thus, as discussed previously (Chapter 4), the factors of deindustrialization, concentration of poverty, and residential segregation are key in explaining why brownfields often occur in impoverished and minority neighborhoods.

The present chapter answers the research question of whether brownfields are in fact disproportionately located in impoverished and minority neighborhoods. Based on the

theoretical framework developed in Chapter 4, this chapter tests three hypotheses from the above research question. First, it hypothesizes that neighborhoods adjacent to brownfields are socioeconomically more disadvantaged than are neighborhoods farther from brownfields. Second, it also hypothesizes that a higher percent of minority populations resides in neighborhoods near brownfields than in neighborhoods farther from brownfields. In addition, race is seen to remain a significant predictor of brownfield locations even when controlling for other variables. Finally, since Morenoff and Sampson (1997) find that relatively affluent minority populations tend to live near ghetto neighborhoods, it is hypothesized that race becomes stronger while socioeconomic characteristics become weaker predictors of brownfield locations as the radii from brownfields increase from 0.5, 1.0, and 1.5 mile.

The order of this chapter is as follows. The next section discusses data and method for this chapter. Because data and method were discussed in the previous chapter, the purpose of the data and method section in this chapter is to briefly remind readers of critical information. The results section presents findings from bi-variate and multivariate analyses of brownfield locations.

6-1 Data and Method

As discussed in the previous chapter, the units of analysis of this chapter are census block groups in a tri-county area in the Detroit region (see Figure 6-1 and 6-2). In terms of variables, two dependent variables exist. One dependent variable is dichotomous, indicating whether or not there is at least one brownfield located within a 0.5,1.0, 1.5, or 2.0 mile radius from block group centroids. The other dependent variable indicates the number of brownfields located within 0.5, 1.0, or 1.5 mile circular buffers from a block group centroid. Independent variables include four categories: racial, socioeconomic, and housing (see Appendix A for detailed information on the construction of these variables). Finally, this chapter will employ the areal apportionment method for descriptive statistics, while the centriod containment method is employed for statistical tests (see Chapter 5 for detailed discussion of these methods).

6-2 Results

For bi-variate analysis, the areal apportionment method is employed to examine the racial and socioeconomic differences of areas within and beyond a 0.5, 1.0, 1.5, and 2.0

mile radii from brownfields in the tri-county area. The centroid containment method is used to determine whether the racial and socioeconomic characteristics of census block groups are statistically significantly correlated with distance to brownfields. Also with regard to applying the centroid containment method, logistic and ordinary least square regressions are performed to examine whether race is an independent predictor of the location of a census block group to a brownfield when controlling for socioeconomic characteristics.

6-2-1 Bi-variate Analysis

Table 6-1 gives descriptive statistics for the tri-county area in the Detroit Primary Metropolitan Statistical Area. Of the 3605 census block groups in this area, 37 census block groups contain no person. Among 3568 census block groups that contain at least one person, the mean percent of non-Hispanic whites is 62.8% with a 39.1% standard deviation. The mean percent of African Americans is 30.1% with a 40.2% standard deviation. The maximum percent of whites and African Americans are both 100% while the maximum percent of Hispanics is 83.8% (see Table 6-1). In terms of socioeconomic variables, the mean percent of female-headed families with dependent children is approximately 10% with a 10% standard deviation. The maximum percent of female-headed families with dependent children and persons below the poverty line are both 100% while the percent of unemployed persons and households receiving public assistance is 66.1% and 53.5%, respectively. The mean percent of persons over 25 with no high school diploma and with a bachelor's degree or higher is both about 21% with 13.7% and 17.8% standard deviations, respectively. In the tri-county area, 5.6% of housing units are vacant with a 7.1% standard deviation. The minimum and maximum percent of all housing variables is 0% and 100%, respectively (see Table 6-1).

Table 6-2 employs the areal apportionment method to provide descriptive statistics for the racial and socioeconomic characteristics of areas located within and beyond 0.5, 1.0, 1.5, and 2.0 miles from brownfields. Approximately 800,000 persons, or 20%, were in 2000 living in areas within a 0.5 mile radius from brownfields. As the radius from brownfields lengthens, 46.3%, 63.8%, and 76.2% of people in the tri-county area lived within 1.0, 1.5, and 2.0 mile radii from brownfields, respectively (see Table 6-2). In terms of the number of census block groups (number of observations) captured by a

0.5, 1.0, 1.5, and 2.0 mile radii from brownfields, centroids of 892 (25.0%), 1955 (54.8%), 2652 (72.5%), and 3065 (83.8%) census block groups are captured, respectively. As noted earlier, scientific evaluation is lacking with respect to the racial and socioeconomic impacts of brownfields on adjacent neighborhoods. This study thus proposes to employ multiple radii from brownfields in examining whether the adverse socioeconomic impacts of brownfields are maintained as the radius from brownfields lengthens.

Differences are apparent in the racial and socioeconomic characteristics between areas within and beyond 0.5, 1.0, 1.5, and 2.0 mile radii from brownfields. In terms of racial characteristics within and beyond a 0.5 mile radius from brownfields, a higher percent of minorities lived in areas within a 0.5 mile radius from brownfields (brownfield area) than in areas beyond a 0.5 mile radius from brownfields (non-brownfield areas). For instance, 53.1% and 10.8% of residents in brownfields areas are African Americans and Hispanics, respectively, whereas 17.9% and 3.6% of residents in non-brownfield areas are African Americans and Hispanics, respectively (see Table 6-2). Socioeconomically, brownfield areas are at greater disadvantage than non-brownfield areas. For example, 8.5% of households in brownfield areas (0.5 mile radius) receive public assistance, and 19.6% of persons are below the poverty line. However, 3.1% of households receive public assistance, and 8.0% of persons are below the poverty line in non-brownfield areas (see Table 6-2). Brownfield areas (0.5 mile radius) show a higher percent of female-headed families with dependent children and unemployed persons than do non-brownfield areas. At the same time, brownfield areas also exhibit lower average household income and housing values than do non-brownfield areas (see Table 6-2).

Residents in brownfield neighborhoods have less educational attainment. For instance, the percent of persons over 25 holding a bachelor's degree or higher and persons over 16 employed in white-collar occupations in brownfield areas (0.5 mile radius) are 14.3% and 25.3%, respectively, while the percents for non-brownfield areas are 25.9% and 36.0%, respectively (see Table 6-2). Notably, a lower percent (3.6%) of residents in brownfield areas are not US citizens than in non-brownfield areas (4.3%: see Table 6-2).

Housing characteristics show that brownfield areas are more unstable than non-

brownfield areas. For instance, a higher percent of housing units in brownfield areas are vacant, and a lower percent of housing units are owner-occupied than in non-brownfield areas. In particular, about 8.8% of housing units in brownfield areas (0.5 mile radius) are vacant while only about 4.8% of housing units in non-brownfield areas are vacant (see Table 6-2). Finally, residents in brownfield areas tend to rely more on local jobs than do residents in non-brownfield areas. That is, 33.4% of residents in brownfield areas (0.5 mile radius) were working and residing at the same place[1] while about 22.5% of residents in non-brownfield areas were working and residing in the same place (see Table 6-2).

Even when the radius from brownfields lengthens from 0.5 to 1.0, 1.5, or 2.0 mile, the pattern observed above is maintained. That is, brownfield areas tend to be socioeconomically disadvantaged and unstable minority neighborhoods (see Table 6-2). However, when the radius lengthens, the magnitude of racial and socioeconomic disparity between brownfield and non-brownfield areas tends to decline. For example, the difference in percent of African Americans between brownfield and non-brownfield areas with a 0.5 mile radius is 35.3% (53.1% versus 17.9%). When the radius is expanded to 1.0, 1.5, and 2.0 mile, the differences in the percent decrease to 33.2%, 30.6%, and 27.6%, respectively. On the other hand, the percent of persons who are not U.S. citizens proves an exception. While brownfield areas with a 0.5 mile radius show lower percent of persons who are not U.S. citizens than do non-brownfield areas (3.6% vs 4.3%: see Table 6-2), brownfield areas with a 2.0 mile radius show a higher percent of persons who are not U.S. citizens than do non-brownfield areas (4.2% vs 3.9%: see Table 6-2).

Table 6-3 presents a correlation matrix that shows statistical significance and reveals significant associations between locations of brownfields and neighborhood racial and socioeconomic conditions. In other words, census block groups within 0.5 and 1.0 mile radii from at least one brownfield are more racially and socioeconomically disadvantaged than are ones beyond 0.5 and 1.0 mile radii from at least one brownfield. In addition, census block groups with a greater number of brownfields within 0.5 and 1.0 mile radii from block group centroids are more racially and socioeconomically disadvantaged than are ones with a lesser number of brownfields within 0.5 and 1.0 mile radii from the

[1] The census bureau defines ‘at the same place’ as the same zip code area.

centroid.

Directions of statistical associations behave in expected ways. For example, as the percent of African Americans in a census block group increases it becomes more likely that this census block group is located within a 0.5 or 1.0 mile radius from at least one brownfield. On the other hand, as the median household income of a census block group increases it is unlikely that this census block group will be located within a 0.5 or 1.0 mile radius from at least one brownfield. For other instance, as the percent of African Americans in a census block group increases, a greater number of brownfields are likely to located within a 0.5 or 1.0 mile radius from the centroid of the census block group. On the other hand, as the median household income of a census block group decreases a greater number of brownfields is likely to be located within a 0.5 or 1.0 mile radius from the centroid of the census block group (see Table 6-3).

When strength of associations is examined, the percents of non-Hispanic whites, African Americans, and persons below the poverty line show stronger associations with the presence of at least one brownfield within a 0.5 mile radius (Pearson's correlation over 0.4: see Table 6-4). When the number of brownfields is examined, the same pattern is observed. That is, impoverished and minority census block groups tend to be located near a greater number of brownfields. When strength of association is probed, Pearson's correlation is highest for the percent of persons below the poverty line (0.419) followed by the percent of non-Hispanic whites (-0.394) and African Americans (0.382: see Table 6-4). In conclusion, bi-variate analyses confirm that brownfield census block groups are more socioeconomically disadvantaged than are non-brownfield census block groups. This analysis also reveals that brownfield census block groups show a higher percent of minority populations than non-brownfield census block groups.

6-2-2 Multivariate Analysis

As discussed in the previous section, impoverished and minority populations tend to live near brownfields. However, simple bi-variate analysis shows associations between the locations or numbers of brownfields and racial and socioeconomic variables. That is, racial variables are possibly associated with the locations and numbers of brownfields mediated through socioeconomic, sociopolitical, and/or housing variables. If this is the case, racial variables are not independent variables in predicting the locations and

numbers of brownfields. Therefore, logistic regression is performed for locations of brownfields, while ordinary linear regression is performed for a number of brownfields. Due to multicollearity with reference to significant associations among independent variables that often involve directional changes (Gujarati 1995), limited numbers of variables are introduced in multivariate models. Noticeably, it appears that occupation variables are highly associated with other socioeconomic variables. That is, when occupational variables are introduced in multivariate models with other socioeconomic variables, the directions of occupational variables change. Therefore, occupational variables are excluded from the multivariate analyses. Variance influence factors for variables included in multivariate models are less than 10, which indicates that no multicollearity exists (Gujarati 1995). In addition to multicollearity, the normality assumption is checked for linear regression by examining standardized normal plots (displaying standardized predicted values and standardized residuals), and no violation of normality is found.

Racial variables are significant predictors of brownfield locations (Model 1 in Table 6-4). As the percent of African Americans and Hispanics increases, the probability that census block groups will be located near at least one brownfield also increases. Socioeconomic variables are significant predictors, and as the percent of persons below the poverty line and the percent of unemployed persons increase and median household income decreases, the probability that census block groups will be located near at least one brownfield increases (Model 2 in Table 6-4). Finally, housing variables appear to be significant; as the percent of vacant housing units increases and the percent of owner-occupied housing units decreases the probability of census block groups located near at least one brownfield increases (Model 3 in Table 6-4). Although each category of variables is a statistically significant predictor of brownfield locations, three variables maintain their explanation power to predict brownfield locations in the full model (Model 4 in Table 6-4). They are the percent of African Americans, median household income ($1000), and percent of vacant housing units maintain their explanatory powers at the minimal 0.05 significance level. Therefore as expected, the percent of African Americans and percent of vacant housing units are positive predictors, while the median household income is a negative predictor of brownfield locations.

When the radius from brownfields lengths from 0.5 to 1.0 mile, the same pattern is observed (Model 1-3 in Table 6-5). That is, all three groups of variables are separately significant predictors of brownfield locations while the coefficient values for all variables increase. In the full model (Model 4 in Table 6-5), five variables maintain their explanation power to predict brownfield locations. They are the (1) percent of African Americans, (2) percent of Hispanics, (3) median household income ($1000), (4) percent of persons below the poverty line, and (5) percent of persons over 25 who do not have high school diplomas. It is notable that the percent of Hispanics gains in explanatory power when the radius from brownfields increases from 0.5 to 1.0 mile, this being so because there are few Hispanics in the study area (less than 4.5% in the tri-county area: see Table 6-2). Given that similar ethnic minorities tend to live close to each other, many Hispanic census block groups are located beyond a 0.5 mile radius yet within a 1.0 mile radius from brownfields.

Although logistic regression demonstrates that the percent of African Americans is a significant predictor of brownfield locations when controlling other variables, this regression does not address the question of whether racial variables are independent predictors of the number of brownfields. To answer this question, ordinary least square regression was performed using a number of brownfields within a 0.5 or 1.0 mile radius from the centroid of census block groups as the dependent variable. All three groups of variables prove to be separate statistically significant predictors of the number of brownfields with a 0.5 mile radius from neighborhood centroids, the same pattern observed in logistic regression (Model 1-3 in Table 6-6). The directions of all variables are the same as observed in logistic regression. The full model is capable of explaining approximately 22% of the variance in the number of brownfields within a 0.5 mile radius from neighborhood centroids (see R^2 Model 4 in Table 6-6). In the full model, four variables maintain their explanation power to predict the number of brownfields. They are the (1) percent of African Americans, (2) percent of persons blow the poverty line, (3) percent of persons over 25 who do not have high school diplomas, and (4) percent of vacant housing units. The directions of variables behave as expected except for the percent of persons employed in blue collar occupations. Given that linear regression presents standardized coefficients, those can be compared to determine which variable is

the strongest predictor. When compared, the percent of African Americans (0.178) is the strongest variable followed by the percent of persons below the poverty line (0.122) and the percent of vacant housing units (0.117: see Beta in Table 6-6).

When the radius expands from 0.5 to 1.0 mile, the explanatory power of the full model (R^2 Model 6 in Table 6-7) increases to 43.3% (21.5% in a 0.5 mile radius). This number signifies that about 45% of the variance in the number of brownfields within a 1.0 mile radius from the neighborhood centroids is explained by variables in this model. Furthermore, all variables except median household income and the percent of owner-occupied housing units are statistically significant predictors of the number of brownfields. Directions of variables behave as expected except for the percent of persons employed in blue collar occupations. Considering standardized coefficients, the strongest predictors are the percent of African Americans (0.305) followed by the percent of persons below the poverty line (0.160) and the percent of vacant housing units (0.129).

Finally, results show that the explanatory power of the percent of African Americans becomes stronger while median household income becomes weaker as the radius from brownfields lengthens from a 0.5 to 1.0 and from a 1.0 to a 1.5 mile. For example, the coefficient of the percent of African Americans in the logistic regression of census block groups within and beyond a 0.5 mile radius from at least one brownfield is 1.159 (see Model 4 in Table 6-4). However, the coefficients in the regression of census block groups within and beyond 1.0 and 1.5 mile radii from at least one brownfield increases to 1.654 (see Model 4 in Table 6-5) and to 2.582 (see Appendix E), respectively. On the other hand, the coefficient of median household income in the logistic regression of census block groups within and beyond a 0.5 mile radius from at least one brownfield is -0.031 (see Model 4 in Table 6-4). The coefficient in the regression of census block groups within and beyond a 1.0 radius from at least one brownfield decreases (-0.022: see Model 4 in Table 6-5) although the coefficient in the regression of census block groups within and beyond a 1.5 radius from at least one brownfield remain the same (-0.022: see Appendix E).

When the number of brownfields is examined, both the percent of African Americans and median household income become stronger predictors as the radius from brownfields lengthens from 0.5 mile to 1.5 mile. For example, the standardized coefficients of the

percent of African Americans increase from 0.178 (see Model 5 in Table 6-6), 0.305 (Model 5 in Table 6-7), and 0.355 (Appendix E) as the radius from brownfields lengths from 0.5, 1.0, and 1.5 mile, respectively. Similarly, standardized coefficients of median household income increase from -0.023 (see Model 5 in Table 6-6), -0.036 (Model 5 in Table 6-7), and -0.048 (Appendix E) as the radius from brownfields lengthens from 0.5, 1.0, and 1.5 mile, respectively. In brief, race becomes stronger predictor of locations of brownfields while income loses its explanatory power as the radius from brownfields lengthens from 0.5 to 1.0 mile. However, both race and income become stronger predictors of the number of brownfields as the radius from brownfields is lengthened. In particular, median household income becomes statistically significant predictor of the number of brownfields within 1.0 and 1.5 mile radii.

That the percent of African Americans becomes a stronger predictor but median household income becomes a weaker predictor when the radius from brownfield expands from a 0.5 to 1.0 mile suggests that relatively wealthy African Americans might live in close proximity to brownfields. In other words, because relatively wealthy African Americans tend to live close to ghetto areas (Morenoff and Sampson 1997), census block groups of residences of relatively wealthy African Americans might also be captured when the radius expands from 0.5 to 1.0 mile. However, when the radius expands from 1.0 to 1.5 mile, median household income does not lose its explanatory power, possibly because many white suburban census block groups are likely to be captured by 1.5 mile circular buffers from brownfields. Because 72.5% of block group centroids (comprised of 63.8% of persons) in the tri-county area are captured by 1.5 mile circular buffers from brownfields, census block groups not captured by circular buffers tend to become highly homogenous (wealthy white suburbs).

In terms of the number of brownfields, both the percent of African Americans and median household income gain in explanatory power as the radius from brownfields expands from a 0.5 to a 1.0 and from a 1.0 to 1.5 mile. In order to offer a clear explanation, it is necessary to differentiate the former dependent variable (the presence of at least one brownfield) from the later dependent variable (the number of brownfields). When the presence or absence of brownfields within these radii from block group centroids is the dependent variable, each census block groups within a 0.5, 1.0, or 1.5

mile radius from brownfields (regardless of their number) carries equal weight. For example, there is no distinction between census block group A in which one brownfield is located within a 1.0 mile radius from its centroid and census block group B in which ten brownfields are located within a 1.0 mile radius from brownfields. Those census block groups are treated as one category (brownfield census block group) as opposed to the other category (non-brownfield census block group located beyond a 1.0 mile radius from brownfield). When the number of brownfields is considered, by contrast, census block groups within a 0.5, 1.0, or 1.5 mile radius from block group centroids make distinct impacts on the model specification, and the impacts are determined on the basis of how many brownfields are located within a 0.5, 1.0, or 1.5 mile radius from block group centroids. Thus, census block group A and B, for instance, carry different weights in the statistical model.

How, then, can the above explain why both the percent of African Americans and median household income gain in explanatory power as radius from brownfields expands from a 0.5 to a 1.0 and from a 1.0 to 1.5 mile? Census block groups with a greater number of brownfields are extremely impoverished with respect to high concentration of African Americans. Also, these census block groups tend to be located at a greater distance from areas where relatively wealthy African Americans reside. Even though the expansion of the radius from a 0.5 to a 1.0 mile or from a 1.0 to a 1.5 mile captures census block groups in which wealthy African Americans reside, the numbers of brownfields near these block groups are not great (chiefly one and two brownfields within a 1.0 or 1.5 mile radius from block group centroids). Possibly, this is why both the percent of African Americans and median household income gain in explanatory powers when the radius is expanded.

In conclusion, statistical analyses in this chapter reveal that brownfields tend to be located near impoverished and minority populations. As well, the racial variable is an independent and stronger predictor than income of the presence of brownfields as well as the number of brownfields. Finally, as radius expands from 0.5 to 1.0 mile, the percent of African Americans gains in explanatory power while median household income loses in explanatory power. The next chapter will present the results of longitudinal analyses of racial and socioeconomic conditions of census block groups within and beyond a 1.0

mile radius from brownfields for the period 1960 to 2000.

Table 6-1 Descriptive statistics of census block groups in the tri-county area in 2000

	N	Mean	Standard Deviation	MIN	MAX
Racial Variables[a]					
% Non-Hispanic Whites	3568	62.8%	39.1%	0.0%	100.0%
% African Americans	3568	30.1%	40.2%	0.0%	100.0%
% Hispanics	3568	2.9%	7.6%	0.0%	83.8%
Socioeconomic Variables					
% Female-head Household with Dependent Children	3560	9.6%	9.8%	0.0%	100.0%
% Unemployed Persons	3561	7.6%	7.6%	0.0%	66.1%
% Households with Public Assistance	3560	5.3%	7.0%	0.0%	53.5%
% Persons below Poverty	3560	12.1%	13.0%	0.0%	100.0%
Average Household Income	3560	$50,315	$25,300	$2,499	$200,001
Average Owner-Occupied Housing Value	3536	$126,283	$90,701	$9,999	$1,000,001
% Not a Citizen	3568	3.5%	5.7%	0.0%	45.8%
% Less than High School Diploma	3567	20.6%	13.7%	0.0%	100.0%
% Bachelor's Degree or Higher	3567	20.5%	17.8%	0.0%	89.7%
% White Collar Occupations	3561	30.20%	16.5%	0.0%	100.0%
% Blue Collar Occupations	3561	26.80%	12.3%	0.0%	100.0%
Housing Variables					
% Occupied Housing Units	3563	5.6%	7.1%	0.0%	100.0%
% Owner-Occupied Housing Units	3560	72.8%	24.8%	0.0%	100.0%

[a] Some racial groups such as Asian and Pacific Islanders, Native Americans, and 2 or more races are excluded in this table.

Table 6-2 Descriptive statistics for the socioeconomic conditions of circular areas within the 0.5, 1.0, 1.5, and 2.0 mile radius from brownfields using the areal apportionment method[a]

	Tri-county area	0.5 mile radius from brownfields		1.0 mile radius from brownfields		1.5 mile radius from brownfields		2.0 mile radius from brownfields	
		Beyond	Within	Beyond	Within	Beyond	Within	Beyond	Within
Numbers of Persons	4,043,467	3,236,388	807,079	2,168,513	1,874,954	1,464,469	2,578,998	963,652	3,079,815
% Persons 16+ who live and work at the same zip code areas	24.6%	22.5%	33.5%	20.2%	29.6%	18.9%	27.5%	18.5%	26.2%
Racial Variables									
% Non-Hispanic Whites	67.3%	74.4%	38.7%	83.0%	49.1%	87.3%	55.9%	88.8%	60.6%
% African Americans	24.9%	17.9%	53.1%	9.5%	42.7%	5.4%	36.0%	3.9%	31.5%
% Hispanics	4.4%	3.6%	10.8%	2.6%	7.8%	2.4%	6.2%	2.3%	5.3%
Socioeconomic Variables									
% Female-head Households	8.2%	6.9%	13.6%	5.3%	11.6%	4.6%	10.2%	4.4%	9.3%
% Unemployed Persons	6.0%	5.1%	10.6%	4.1%	8.6%	3.6%	7.6%	3.5%	6.9%
% Households with Public Assistance	4.2%	3.1%	8.5%	2.0%	6.7%	1.6%	5.7%	1.4%	5.0%
% Persons below Poverty	10.2%	8.0%	19.6%	5.6%	15.6%	4.7%	13.4%	4.4%	12.0%
Average Household Income	$63,647	$68,002	$45,702	$74,593	$50,908	$78,792	$55,140	$81,707	$58,215
Average Housing Value	$157,820	$168,930	$99,380	$188,111	$114,456	$200,928	$129,011	$209,387	$139,364
% Not a Citizen	4.1%	4.3%	3.6%	4.3%	4.0%	4.1%	4.2%	3.9%	4.2%
% Less than High School Diploma	18.1%	15.9%	27.2%	13.3%	23.9%	12.0%	21.7%	11.7%	20.1%
% Bachelor's Degree or Higher	23.7%	25.9%	14.3%	29.1%	17.1%	30.8%	19.5%	30.9%	21.4%
% White Collar Occupations	34.2%	36.0%	25.3%	38.6%	28.0%	40.0%	30.3%	40.0%	32.1%
% Blue Collar Occupations	24.7%	23.8%	29.1%	22.4%	27.9%	21.9%	26.6%	22.3%	25.5%
Housing Variables									
% Vacant Housing Units	5.5%	4.6%	8.8%	4.0%	7.1%	4.0%	6.3%	4.0%	5.9%
% Owner-Occupied Housing Units	71.5%	74.7%	58.5%	78.3%	63.7%	79.7%	67.0%	81.4%	68.6%

[a] Census Block groups were used as building blocks of areas in this table

[b] Some racial groups such as Asian and Pacific Islanders, Native Americans, and 2 or more races are excluded in this table.

Table 6-3 Correlation matrix between locations of brownfields and socioeconomic conditions of census block groups by employing the centroid containment method

	Number of Census block groups	Whether census blocks are located within a 0.5 radius from at least one brownfield[a]		Whether census blocks are located within a 1.0 radius from at least one brownfield[b]		Numbers of Brownfield within a 0.5 mile radius from block group centroids		Numbers of Brownfield within a 1.0 mile radius from block group centroids	
		(a)		(b)		(c)		(d)	
Racial Variables									
% Non-Hispanic Whites	3568	-0.419	***	-0.452	***	-0.394	***	-0.587	***
% African Americans	3568	0.404	***	0.429	***	0.382	***	0.569	***
% Hispanics	3568	0.064	***	0.087	***	0.060	***	0.078	***
Socioeconomic Variables									
% Female-head Household with Dependent Children	3560	0.330	***	0.359	***	0.296	***	0.438	***
% Unemployed Persons	3561	0.370	***	0.361	***	0.352	***	0.518	***
% Households with Public Assistance	3560	0.374	***	0.381	***	0.367	***	0.511	***
% Household below Poverty	3560	0.431	***	0.422	***	0.419	***	0.586	***
Median Household Income	3560	-0.368	***	-0.433	***	-0.333	***	-0.464	***
Median Owner-Occupied Housing Value	3536	-0.306	***	-0.386	***	-0.270	***	-0.393	***
% Not a Citizen	3568	-0.048	**	-0.023		-0.041	*	-0.056	**
% Less than High School Diploma	3567	0.370	***	0.400	***	0.354	***	0.489	***
% Bachelor's Degree or Higher	3567	-0.270	***	-0.327	***	-0.236	***	-0.338	***
% White Collar Occupations	3561	-0.284	***	-0.346	***	-0.247	***	-0.353	***
% Blue Collar Occupations	3561	0.165	***	0.222	***	0.145	***	0.186	***
Housing Variables									
% Occupied Housing Units	3563	0.281	***	0.245	***	0.327	***	0.425	***
% Owner-Occupied Housing Units	3560	-0.320	***	-0.313	***	-0.328	***	-0.443	***

[a] zero means that census block groups are located beyond while one means that census block groups are located within a 0.5 mile radius from brownfields.

[b] zero means that census block groups are located beyond while one means that census block groups are located within a 1.0 mile radius from brownfields.

* $p > 0.05$ ** $p > 0.01$ *** $p > 0.001$

Table 6-4 Logistic regression[a] based on the centroid containment method (0.5 mile radius from brownfields and census block groups as units of analysis)

	Model 1 (N=3567)		Model 2 (N=3558)		Model 3 (N=3559)		Model 4 (N=3558)	
	B		B		B		B	
Constant	-2.122	***	-0.228		-0.074		-0.780	**
Racial Variables								
%African Americans	2.354	***					1.159	***
%Hispanics	3.619	***					0.988	
Socioeconomic Variables								
Median Household Income ($1000)			-0.035	***			-0.031	***
%Persons Unemployed			2.778	***			0.535	
%Persons below the Poverty Line			2.330	***			0.736	
%Less than High School Diploma			0.287				0.727	
Housing Variables								
%Vacant Housing Units					6.485	***	1.597	*
%Owner-Occupied Housing Units					-2.077	***	0.193	
Model								
Chi^2	607.1	***	741.1	***	434.2	***	816.1	***
-2 Log likelihood	3405.8		3257.7		3567.4		3182.7	

[a] zero means that census block groups are located beyond while one means that census block groups are located within a 0.5 mile radius from brownfields.
* p > 0.05 ** p > 0.01 *** p > 0.001

Table 6-5 Logistic regression[a] based on the centroid containment method (1.0 mile radius from brownfields and census block groups as units of analysis)

	Model 1 (N=3567)		Model 2 (N=3558)		Model 3 (N=3559)		Model 4 (N=3558)	
	B		B		B		B	
Constant	-0.660	***	0.372		1.472	***	0.032	
Racial Variables								
%African Americans	2.725	***					1.654	***
%Hispanics	5.277	***					1.780	*
Socioeconomic Variables								
Median Household Income ($1000)			-0.021	***			-0.022	***
%Persons Unemployed			3.829	***			0.027	
%Persons below the Poverty Line			4.374	***			1.911	*
%Less than High School Diploma			1.001				1.541	**
Housing Variables								
%Vacant Housing Units					6.264	***	-0.022	
%Owner-Occupied Housing Units					-2.157	***	0.455	
Model								
Chi^2	809.0	***	939.3	***	436.6	***		
-2 Log likelihood	4106.4		3963.7		4467.6			

[a] zero means that census block groups are located beyond while one means that census block groups are located within a 1.0 mile radius from brownfields.
* p > 0.05 ** p > 0.01 *** p > 0.001

Table 6-6 Linear regression for the number of brownfields within the 0.5 mile radius from centroids of census block groups

	Model 1 (N=3567)			Model 2 (N=3558)			Model 3 (N=3559)			Model 4 (N=3558)		
	B	Beta		B	Beta		B	Beta		B	Beta	
Constant	0.103		***	0.138		*	0.768		***	0.117		
Racial Variables												
%African Americans	0.872	0.397	***							0.388	0.178	***
%Hispanics	1.289	0.111	***							0.162	0.014	
Socioeconomic Variables												
Median Household Income ($1000)				-0.002	-0.062	**				-0.001	-0.023	
%Persons Unemployed				1.033	0.090	***				0.183	0.016	
%Persons below the Poverty Line				1.883	0.277	***				0.830	0.122	***
%Less than High School Diploma				0.326	0.051	**				0.514	0.080	**
Housing Variables												
%Vacant Housing Units							3.082	0.230	***	1.561	0.117	***
%Owner-Occupied Housing Units							-0.740	-0.209	***	-0.141	-0.040	
Model												
R^2		0.158	***		0.187	***		0.146	***		0.215	***

* p > 0.05 ** p > 0.01 *** p > 0.001

Table 6-7 Linear regression for the number of brownfields within the 1.0 mile radius from centroids of census block groups

	Model 1 (N=3567)			Model 2 (N=3558)			Model 3 (N=3559)			Model 4 (N=3558)		
	B	Beta		B	Beta		B	Beta		B	Beta	
Constant	0.428		***	0.612		***	2.901		***	0.366		*
Racial Variables												
%African Americans	3.363	0.589	***							1.733	0.305	***
%Hispanics	4.643	0.155	***							1.150	0.038	**
Socioeconomic Variables												
Median Household Income ($1000)				-0.008	0.086	***				-0.003	-0.036	
%Persons Unemployed				5.401	0.180	***				1.910	0.064	**
%Persons below the Poverty Line				6.603	0.372	***				2.832	0.160	***
%Less than High School Diploma				0.730	0.044	*				1.392	0.083	***
Housing Variables												
%Vacant Housing Units							10.634	0.305	***	4.499	0.129	***
%Owner-Occupied Housing Units							-2.637	-0.285	***	-0.280	-0.030	
Model												
R^2		0.348	***		0.374	***		0.264	***		0.433	***

* p > 0.05 ** p > 0.01 *** p > 0.001

Figure 6-1 Census Block Group Map of Brownfield Locations in the Tri-county Area

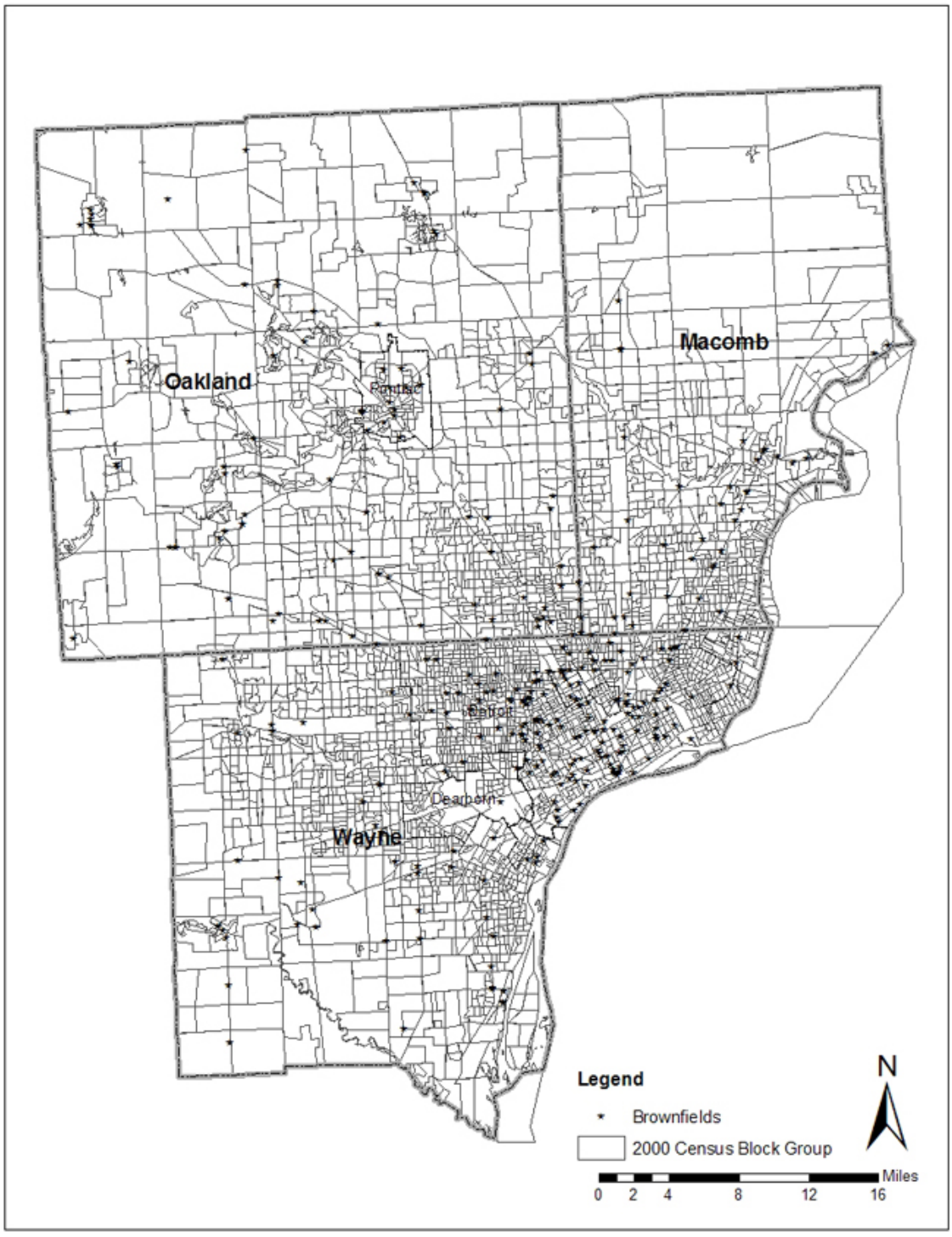
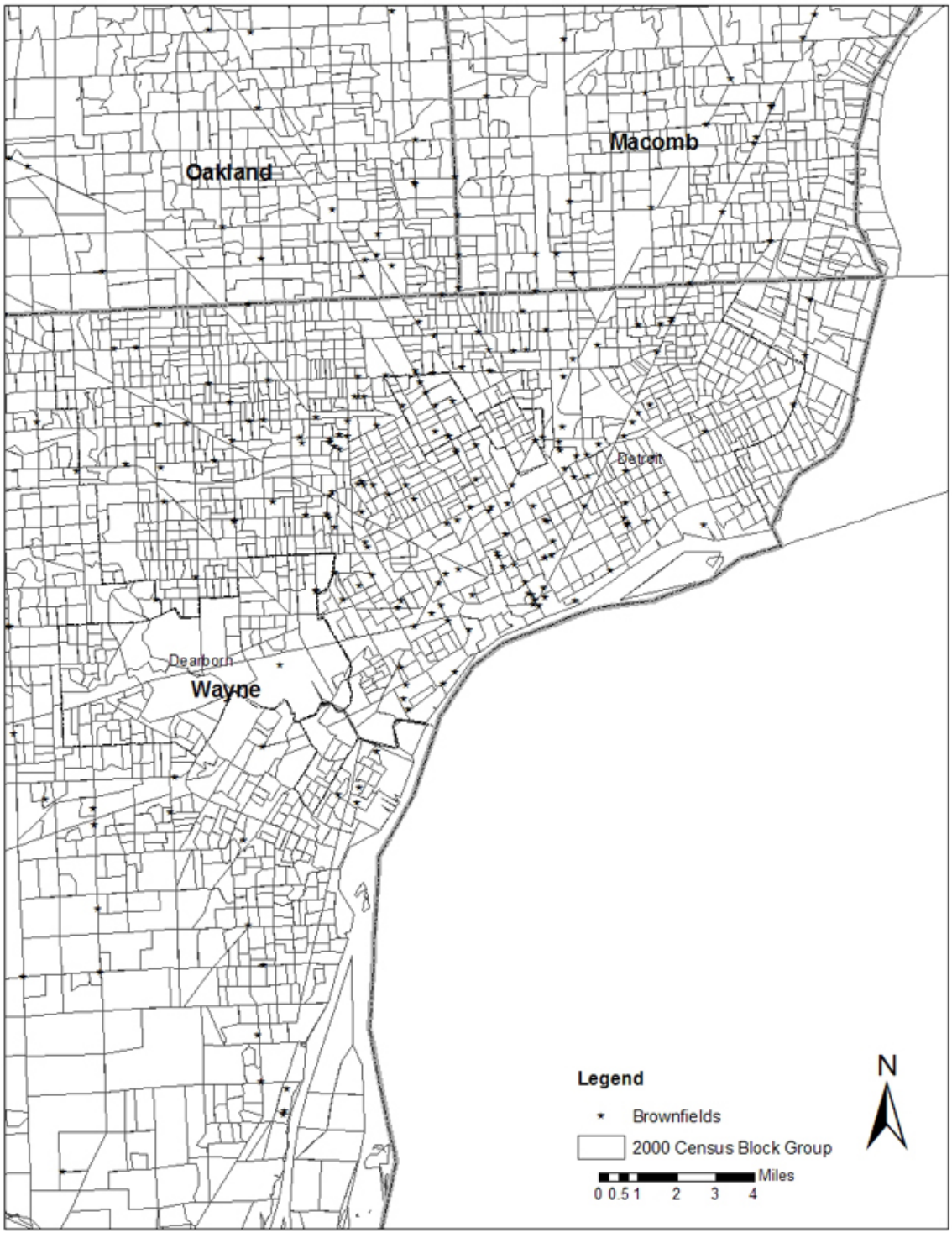


Figure 6-2 Census Block Group Map of Brownfield Locations in the Detroit Area



CHAPTER 7: LONGITUDINAL ASSESSMENT OF RACIAL AND SOCIOECONOMIC CHANGES IN BROWNFIELD AND NON-BROWNFIELD NEIGHBORHOODS FROM 1960 TO 2000

The previous chapter presented results from cross-sectional assessments of racial and socioeconomic conditions of brownfield and non-brownfield neighborhoods, and finds that brownfields tend to be located near impoverished and minority neighborhoods. Results also indicate that race is an independent and in fact stronger predictor than income of locations and numbers of nearby brownfields. These results are consistent with recent environmental justice studies of locations of environmentally adverse facilities such as hazardous waste facilities, Toxic Release Inventory facilities, and municipal landfills, race being an independent and stronger predictor of such facilities (Mohai and Saha 2007; Ringquist 2005[1]). Cross-sectional analysis addresses whether locational disparity of brownfields currently exists; however, it does not answer how locational disparity has come to evolve in the Detroit region.

Thus, the objective of this chapter is to examine whether the presence of brownfields is associated with the decline of socioeconomic conditions of adjacent neighborhoods. As argued in chapter 4, the creation of brownfields between 1960 and 1970 is not necessarily the result of decline in socioeconomic conditions of neighborhoods adjacent to brownfields. Rather, brownfields are concomitant with deindustrialization, or the departure of manufacturing establishments from U.S. central cities to suburbs, other states, or even other countries, all of which left a trail of abandoned establishments. Arguably the emergence of the early brownfields (category 1) resulted in the decline in socioeconomic conditions of adjacent neighborhoods after 1970 because deindustrialization eliminated manufacturing jobs even for adjacent neighborhoods. Decline in socioeconomic conditions further led to the emergence of yet more brownfields (category 2) composed of local service business establishments such as gas

[1] The author randomly selects 60 past environmental justice studies (out of 297 studies) and conducts a meta-analysis.

stations, junk yards, and body shops. Therefore, this chapter tests the hypothesis that the socioeconomic decline of areas within 1.0 mile circular buffers from brownfields in fact accelerated after 1970. That is, did the racial and socioeconomic characteristics of areas within 1.0 mile circular buffers from brownfields diverge from those of areas beyond 1.0 mile more rapidly after 1970 than they did before 1970?

7-1 Data and Method

As discussed in chapter 5, the areal apportionment method is used for descriptive statistics when brownfield and non-brownfield areas are determined due to inconsistent census tract boundaries between 1960 and 1970 and onward. Brownfield areas refer to areas within 1.0 mile circular buffers from brownfields, while non-brownfield areas refer to areas beyond 1.0 mile. Racial and socioeconomic characteristics of brownfield areas are aggregated on the basis of proportions of the areas in census tracts captured by these circular buffers from brownfields. Similarly, racial and socioeconomic characteristics of non-brownfield areas are aggregated on the basis of proportions of the areas in census tracts beyond these circular buffers. For statistical analysis, from 1960 to 2000 percentage changes in socioeconomic characteristics of areas within a 1.0 mile radius from brownfields (N=355) are compared to the percentage changes of areas within a 1.0 mile radius from random points (N=355). This chapter employs a bi-variate analysis, or a simple independent sample t-test, and so does not employ multivariate analysis because the purpose of this analysis is to compare trends of racial and socioeconomic changes from 1960 to 2000 between brownfield and non-brownfield areas.

As mentioned in chapter 5, many variables available in the 1970. Census and thereafter were not available in 1960. Thus, racial and socioeconomic variables used in this chapter are those that are available in the 1960 Census and onward. The variables are: (1) the percent of whites, (2) the percent of African Americans, (3) average family income, (4) average owner-occupied housing values, (5) the percent of unemployed persons, (6) the percent of persons over 25 who do not possess a high school diploma, (7) the percent of owner-occupied housing units, and (8) the percent of vacant housing units (for detailed discussion with respect to the constructions of those variables, see Appendix B). Average family income and average values for owner-occupied housing units in 1959, 1969, 1979, and 1989 are adjusted to 1999 dollars by use of a consumer price index

inflation calculator[2]. The inflation ratios of 1959, 1969, 1979, and 1989 to 1999 dollars were 5.73, 4.54, 2.29, and 1.34, respectively.

7-2 Results

This section has three parts. In the first, the racial and socioeconomic characteristics of the entire study area from 1960 to 2000 are displayed. The second gives simple descriptive analyses with respect to changes in the racial and socioeconomic characteristics between brownfield and non-brownfield neighborhoods by decades. The third and final part includes statistical tests that indicate whether the mean percentage differences in socioeconomic characteristics between brownfield and non-brownfield neighborhoods by decades are statistically significant.

7-2-1 Racial and Socioeconomic Characteristics in the Study Area

Table 7-1 shows the racial and socioeconomic characteristics of the study area from 1960 to 2000. In terms of aggregate number, the total number of whites in this area increased from 1960 to 1970 but began declining after 1970. On the other hand, the total African American population constantly increased from 1960 to 2000. The number of unemployed persons decreased from 1960 to 1970 but greatly increased from 1970 to 1980 (from 93,409 in 1960 to 218,235 in 1970), but the number began to decline from 1980 to 2000. Average family income increased from 1960 to 2000, but income greatly increased in the 1960s (from $44,692 in 1960 to $61,602 in 1970) and 1990s (from $65,215 in 1990 to $74,000 in 2000) as compared to other decades. Average values for owner-occupied housing units increased from 1960 to 1980 (from $82,248 in 1990 to $114,374 in 2000) but declined between 1980 and 1990. This value, then, began to increase greatly between 1990 and 2000 (from $111,135 in 1990 to $164,112 in 2000). The total number of persons who do not have high school diplomas continuously declined from 1960 to 2000. The number of vacant housing units decreased from 1960 to 1970 but grew from 1970 to 2000. Finally, the number of owner-occupied housing units continued increasing from 1960 to 2000.

In addition, the percent of whites continuously declined from 1960 (85%) to 2000 (70%) while the percent of African Americans continuously increased during the same period (15% in 1960 to 26% in 2000). The percent of unemployed persons declined in

[2] The web-based calculator is available at http://www.bls.gov/cpi/.

the 1960s (8% in 1960 to 6% in 1970) but doubled in the 1970s (from 6% in 1970 to 12% in 1980), starting to fall from 1980 to 2000 (12% in 1980 to 6% in 2000). The percent of persons who do not have high school diplomas continuously declined from 1960 to 2000 (59% in 1960 to 18% in 2000). The percent of vacant housing units decreased by 2% in the 1960s (6% in 1960 to 4% in 1970) but increased by 1% between 1970 and 2000 (4% in 1970 to 5% in 2000). Finally, the percent of owner-occupied housing units increased in the 1960s (71% in 1960 to 74% in 1970) but declined in the 1970s and 1980s (73% in 1970 to 69% in 1990), bouncing back 3% in the 1990s (69% in 1990 to 72% in 2000) (see Table 7-1).

7-2-2 Racial and Socioeconomic Characteristics of Neighborhoods from 1960 to 2000

In general, areas within a 1.0 mile radius from brownfields show a higher percent of African Americans than do areas beyond a 1.0 mile radius from brownfields from 1960 to 2000. For example, the percent of African Americans in areas within a 1.0 mile radius from brownfields (brownfield areas) in 1960 was 21%, whereas the percent in areas beyond a 1.0 mile radius from brownfields (non-brownfield areas) in the same year was 3% (see Table 7-2). This percent in brownfield areas increased to 27%, 36%, 40%, and 43% from 1970, 1980, 1990, and 2000, respectively, while the percent in non-brownfield areas also increased to 3%, 5%, 7%, and 10% from 1970, 1980, 1990, and 2000, respectively. Although both types of areas experienced an increase in the percent of African Americans, differences in percent of African Americans between brownfield and non-brownfield areas had been consistently positive from 1960 to 2000.

In addition, brownfield areas in general have been socioeconomically more disadvantaged than have been non-brownfield areas. For instance, the average family income in brownfield areas was $41,786 in 1960 while this income in non-brownfield areas was $50,518 in the same year (see Table 7-2). The incomes in brownfield areas were consistently lower than the incomes in non-brownfield areas for later years. The average values for owner-occupied housing units between brownfield and non-brownfield areas evince the same pattern (see Table 7-2). Similarly, the percent of unemployed persons in brownfield areas from 1960 to 2000 was higher than in non-brownfield areas in the same years (see Table 7-2).

Finally, brownfield neighborhoods are more unstable than are non-brownfield

neighborhoods. The percent of vacant housing units was approximately same in brownfield (6.4%) and non-brownfield (6.0%) areas in 1960 (see Table 7-2). However, noticeable differences in the percent of vacant housing units between brownfield and non-brownfield neighborhoods were observed after 1970. For example, this percent in brownfield neighborhoods decreased to 5% in 1970, whereas the percent in non-brownfield neighborhoods decreased to 3% in 1970. The gap between brownfield and non-brownfield neighborhoods widened after 1980. The percent of owner-occupied housing units in brownfield areas was consistently lower than the percent in non-brownfield areas from 1960 to 2000 (see Table 7-2).

In terms of changes by decades in the socioeconomic characteristics, an interesting pattern emerged. Both brownfield and non-brownfield areas experienced socioeconomic improvement between 1960 and 1970. Average family income in brownfield areas, for example, increased from $41,786 in 1960 to $55,791 in 1970 while this income in non-brownfield areas increased from $50,518 in 1960 to $70,377 in 1970 (see Table 7-2). Whereas brownfield areas experienced a 34% increase in this income between 1960 and 1970, non-brownfield areas experienced a 39% increase in this income in this decade. The average values for owner-occupied housing units also increased 17% and 30% in brownfield and non-brownfield areas between 1960 and 1970. The percent of unemployed persons also shows that both brownfield and non-brownfield areas experienced 21% and 34% decreases, respectively, between 1960 and 1970 (see Table 7-2). Although degree of socioeconomic improvement in non-brownfield areas was greater than in brownfield areas, both neighborhoods experienced a marked socioeconomic improvement between 1960 and 1970.

However, a different pattern was observed between 1970 and 1980, meaning that the socioeconomic characteristics in brownfield areas decreased whereas the same characteristics in non-brownfield areas increased over these two decades. The average family income in brownfield areas decreased from $55,791 in 1970 to $54,577, or a 2% decrease. By contrast, the income in brownfield areas increased from $70,377 in 1970 to $73,334 in 1980, or a 4% increase (see Table 7-2). Similarly, the average values for owner-occupied housing units in brownfield areas decreased from $89,573 in 1970 to $86,976 in 1980, or a 3% decrease in this period. On the other hand, the values in non-

brownfield areas increased from $118,653 in 1970 to $142,657 in 1980, or a 20% increase in this period (see Table 7-2). Finally, the percent of unemployed persons showed that both brownfield and non-brownfield areas experienced increases in the percent of unemployed persons between 1970 and 1980 (see Table 7-2). However, while brownfield areas experienced a 122% increase in the percent of unemployed persons in this decade, a 98% increase in this percent in non-brownfield areas was found for the same period.

While the average family income in brownfield areas continued to decline between 1980 and 1990, the income in non-brownfield areas continued to increase over this decade. Both brownfield and non-brownfield areas experienced increases in this income between 1990 and 2000 (see Table 7-2). Both brownfield and non-brownfield areas experienced decreases in the average values for owner-occupied housing units between 1980 and 1990, but those values increased in both areas between 1990 and 2000 (see Table 7-2). Finally, the percent of unemployed persons in both brownfield and non-brownfield neighborhoods began to decline after 1980, but percentage decreases in non-brownfield areas were greater than in brownfield areas from 1980 to 2000. In short, all three variables indicate that a clear divergence in socioeconomic characteristics between brownfield and non-brownfield areas began to emerge after 1970 (see Figure 7-1, 7-2, and 7-3 for graphical illustration).

It is possible that changes in racial and socioeconomic characteristics between brownfield and non-brownfield areas from 1960 to 2000 differ between the city and suburbs. To examine the differences in patterns, study areas are dichotomized by areas within the city of Detroit and areas outside the city of Detroit (representing suburbs). Table 7-3 shows the racial and socioeconomic characteristics between brownfield and non-brownfield neighborhoods by locations. No differences in patterns between the city and suburbs are found. That is, in both the city of Detroit and in its suburbs, brownfield areas have had a higher percent of minorities and have been more socioeconomically disadvantaged than non-brownfield areas. In addition, irrespective of locations a clear divergence in socioeconomic characteristics occurred after 1970, meaning that brownfield and non-brownfield neighborhoods experienced socioeconomic improvements only in the decade between 1960 and 1970.

Although examination of the percents of racial groups from 1960 to 1970 reveals that brownfield areas had gained a higher percent of African Americans than had non-brownfield areas, it does not address whether brownfield areas gained or lost whites and/or African Americans from 1960 to 2000. An examination of the changes in numbers of each racial group from 1960 to 2000 can determine whether decline in socioeconomic conditions of brownfield neighborhoods is associated with overall loss of population. In other words, is the decline in socioeconomic conditions associated with the fact that wealthy whites were leaving and/or impoverished African Americans were moving in.

While brownfield areas lost white population, from approximately 2 million in 1960 to approximately 1 million in 2000 (50% decline), non-brownfield areas gained white population from 1.2 million in 1960 to 1.8 million in 2000 (54% increase) in the tri-county area. On the other hand, although both brownfield and non-brownfield areas gained African American population, from 1960 to 2000, non-brownfield areas experienced a faster growth (from 35,346 in 1960 to 211,722 in 2000, or a 499% increase) than did brownfield areas (523,444 in 1960 to 821,997 in 2000, or a 57% increase) (see Table 7-4). Therefore, a greater increase in percent of African Americans for brownfield areas than for non-brownfield areas from 1960 to 2000[3] resulted from a combination of loss of whites and gain of African Americans in brownfield areas. Although it appears that non-brownfield areas experienced a greater percentage growth in African American populations from 1960 to 2000 than did brownfield areas, the absolute numbers of African Americans in non-brownfield areas in 1960 began much smaller than in brownfield areas (35,346 vs. 523,444 in 1960 for non-brownfield and brownfield areas, respectively) and remained smaller in 2000 despite the increase (see Table 7-4).

For the city of Detroit, both brownfield and non-brownfield areas experienced rapid white loss. For example, the number of whites in non-brownfield areas decreased from 153,940 in 1960 to 21,653 in 2000, an 85% decline for this period. White loss for brownfield areas from 1960 to 2000 is more serious than for non-brownfield areas (1,029,019 in 1960 to 100,483 in 2000, or a 90% decline) (see Table 7-4). African

[3] The percent of African Americans in brownfield areas increased from 21% in 1960 to 43% in 2000, while the percent in non-brownfield areas increased from 3% in 1960 to 10% in 2000 (see Table 7-2).

Americans increased for both brownfield and non-brownfield areas from 1960 to 2000. In particular, more than 200,000 African Americans (a 45% increase) moved to brownfield areas from 1960 to 2000 whereas more than 87,000 African Americans (a 691% increase) moved to non-brownfield areas in this period. When examining the percentage decline of the number of whites in the city of Detroit, an interesting pattern emerged. The highest (-50%) and lowest (-31%) percentage decline of whites in the city occurred in the 1970s and 1960s, respectively, which indicates that the Detroit riots in 1967[4] and the emergence of the Coleman Young administration might have played a critical role in greater white flight from the city in the 1970s and subsequent decades.

For suburbs, non-brownfield areas gained (from 1,054,376 in 1960 to 1,808,028in 2000 or a 71% increase), but brownfield areas lost whites (from 946,547 in 1960 to 899,636 in 2000 or a 5% decrease) between 1960 and 2000. However, brownfield areas gained white population, from 946,547 in 1960 to 1,114289 in 1970 (an 18% increase). The number of whites in brownfield areas decreased from 1970 onward. Both brownfield and non-brownfield areas in suburbs gained African American population between 1960 and 2000. However, non-brownfield areas lost African Americans, from 22,713 in 1960 to 19,139 in 1970 (a 14% decrease) but gained African Americans from 1970 onward (see Table 7-4).

To test the robustness of the results by use of the areal apportionment method, the above analyses were repeated using the 50% areal containment method with census tracts as the units of analysis. In applying this method, racial and socioeconomic characteristics of census tracts for which at least 50% of their areas are captured by 1.0 mile circular buffers from brownfields were aggregated. Racial and socioeconomic characteristics of census tracts for which less than 50% of their areas are captured by 1.0 mile circular buffers from brownfields are also aggregated. Identical results were found, meaning that it does not matter which method is used (see Appendices F-H).

7-2-3 Difference in Percentage Changes in Socioeconomic Characteristics of Areas within a 1.0 Mile Radius from Brownfields from 1960 to 2000

Descriptive statistics show that a higher percent of minority populations lived in

[4] Because the Detroit riot occurred in the late half of the 1960s, its impact on white flight is more likely to become apparent in the 1970s.

brownfield rather than in non-brownfield neighborhoods from 1960 to 2000. Brownfield neighborhoods have proven more socioeconomically disadvantaged as well as more unstable than have non-brownfield neighborhoods. Comparisons of the socioeconomic characteristics between brownfield and non-brownfield neighborhoods reveal that their socioeconomic characteristics clearly diverged after 1970, meaning that socioeconomic characteristics in brownfield neighborhoods began to decline while socioeconomic characteristics in non-brownfield neighborhoods continued to improve after 1970. Although these findings are noteworthy, the analysis thus far has not tested whether the patterns of socioeconomic changes between brownfield and non-brownfield neighborhoods from 1960 to 2000 are statistically significant. To make statistical tests, the socioeconomic characteristics of areas within a 1.0 mile radius from each brownfields (N=355) were estimated using the areal apportionment method. As a comparison group, 355 random points in the tri-county area were generated, and the socioeconomic characteristics of areas within a 1.0 mile radius from each random point were estimated by using the areal apportionment method.

Examinations of differences in percentage changes in racial and socioeconomic characteristics from 1960 to 2000 reveal that the differences between brownfield and non-brownfield areas were statistically significant. For instance, 14% and 0.4% decreases in the percent of whites from 1960 to 1970 were observed in brownfield and non-brownfield areas, respectively. The difference in changes between the two areas was -14%[5] (see Table 7-5 (a)). This difference in changes between the two areas increased between 1970 and 1980, for a -18% difference (see Table 7-5 (b)). The change in average family income from 1960 to 1970 was 14% and 38% in brownfield and non-brownfield areas, respectively, or a -24% difference between brownfield and non-brownfield areas (see Table 7-5 (a)). The difference in changes in this variable between the two areas also grew between 1970 and 1980 to a -31% difference (see Table 7-5 (b)). When the difference in percentage change in the percent of unemployed persons between the two areas in the 1960s is examined, a different pattern became evident. Brownfield areas experienced a 17% decrease in this percent while a 13%

[5] Differences between brownfield and non-brownfield areas mean that racial and socioeconomic characteristics of brownfields are subtracted by racial and socioeconomic characteristics of random points.

increase in the percent in non-brownfield areas was found, meaning that brownfield areas enjoyed a greater improvement in employment between 1960 and 1970 (see Table 7-5 (a)). However, the difference in percentage change in this percent for brownfield areas from 1970 and 1980 increased 135% whereas the difference in this variable for non-brownfield area in this period increased 88%, or a 46% difference between brownfield and non-brownfield (see Table 7-5 (b)). Figure 7-4, 7-5, and 7-6 provide graphical illustrations of the difference in percentage changes in average family income, average values for owner-occupied housing units, and percent of unemployed persons between brownfield and non-brownfield areas from 1960 to 2000, figures that clearly show that brownfield and non-brownfield areas experienced socioeconomic decline and improvement, respectively, after 1970.

In terms of statistical significance, the differences in percentage changes in all the socioeconomic characteristics between brownfield and non-brownfield areas were statistically significant at minimally the 0.01 level between 1960 and 1970 (see Table 7-5 (a)). Differences in percentage changes in all the socioeconomic characteristics between the two areas also were statistically significant at minimally the 0.01 level between 1970 and 1980 (see Table 7-5 (b)). Differences in percentage changes in all the socioeconomic characteristics except the percent of vacant housing units between the two areas were statistically significant at minimally the 0.05 level between 1980 and 1990 (see Table 7-5 (c)). Between 1990 and 2000, differences in percentage changes in all the socioeconomic characteristics except the percent of owner-occupied housing units between the two areas were statistically significant at minimally the 0.05 level (see Table 7-5 (d)).

In conclusion, brownfield areas exhibited higher concentrations of minority and lower socioeconomic characteristics from 1960 to 2000. Whites moved away, but African Americans moved into brownfield neighborhoods. In addition to their racial composition, brownfield neighborhoods experienced a greater decline in all socioeconomic characteristics over all decades than did non-brownfield areas, except the percent of unemployed persons between 1960 and 1970. However, socioeconomic conditions between brownfield and non-brownfield areas diverged from 1970 onward, meaning that the socioeconomic conditions of brownfield decline while those in non-

brownfield areas improve. The decline in brownfield neighborhoods confirms the hypothesis that deindustrialization in the 1960s leading to loss of manufacturing jobs for adjacent residents coupled with abandonment of manufacturing facilities led to a decline in the socioeconomic conditions of adjacent neighborhoods in the 1970s. Based on findings presented in this chapter, it is argued that the worsening socioeconomic conditions beginning in 1970 could have led to the inability of nearby populations to support local service establishments and resulted in their abandonment in those neighborhoods, which in turn gave rise to additional brownfields.

This chapter shows an associations rather than causal relationships between the presence of brownfields and changes in racial and socioeconomic characteristics of areas adjacent to brownfields from 1960 to 2000 because demonstrating causality would minimally require knowing the dates of facility abandonment (see chapter 5). In recall of chapter 4, it was argued that category 1 brownfields emerged due to the deindustrialization of the 1960s that in turn led to the socioeconomic decline in adjacent neighborhoods of the 1970s. It was further argued that category 2 brownfields emerged near neighborhoods that experienced the socioeconomic decline of the 1970s. The pattern of results in this chapter is consistent with the foregoing arguments and presents a first step toward their evaluation. That is, the pattern of results was as predicted based on these arguments. However, data that are currently unavailable[6] would be required to more conclusively test these arguments.

Although the above results suggest that socioeconomic characteristics between brownfield and non-brownfield areas clearly diverged after 1970, a question remains unanswered: Are changes in socioeconomic characteristics between brownfield and non-brownfield neighborhoods statistically significantly different for neighborhoods that share similar socioeconomic characteristics in the initial time period? An Answer to this question will provide more clear evidence of an association between the presence of brownfields and changes in socioeconomic characteristics in adjacent neighborhoods. That is, although brownfield neighborhoods were more socioeconomically disadvantaged neighborhoods than were non-brownfield neighborhoods in 1960, it is unclear whether

[6] At a minimum, data that would help to distinguish category 1 and 2 brownfields are needed. The dates of facility abandonment are also needed.

brownfield neighborhoods that were relatively wealthy existed in 1960 and 1970. If they existed, whether these neighborhoods also experienced socioeconomic decline after 1970 needs to be examined. The next chapter will thus examine changes in racial and socioeconomic characteristics between brownfield and non-brownfield census tracts from 1970 to 2000 when controlling for socioeconomic conditions in 1970. Cluster analysis is used to determine whether relatively wealthy neighborhoods experienced socioeconomic decline after 1970.

Table 7-1 Descriptive statistics of the aggregated census tracts in the tri-county area from 1960 to 2000

	Aggregate Number					Percent				
	1960	1970	1980	1990	2000	1960	1970	1980	1990	2000
Whites	3,187,383	3,392,779	3,088,415	2,877,749	2,829,800	84.68%	81.70%	76.37%	73.55%	69.98%
African Americans	558,790	740,658	885,715	936,204	1,033,719	14.85%	17.84%	21.90%	23.93%	25.57%
Average Family Income[a]	$44,692	$61,602	$63,390	$65,215	$74,000					
Average Housing Values[a]	$82,248	$102,296	$114,374	$111,135	$164,112					
Unemployed Person	111,696	93,409	218,235	173,578	119,470	7.76%	5.67%	11.66%	8.99%	6.05%
Persons without High School Diplomas	1,230,364	1,048,460	776,518	617,208	478,594	59.09%	47.67%	33.07%	24.55%	18.07%
Vacant Housing Units	72,792	52,337	73,497	84,226	89,669	6.31%	4.01%	4.96%	5.47%	5.47%
Owner-Occupied Housing Units	767,758	915,333	995,408	1,001,504	1,108,065	71.05%	73.14%	70.64%	68.78%	71.55%
Number of Census Tracts	781	1165	1165	1165	1165	781	1165	1165	1165	1165

[a] Adjusted in 1999 Dollar Value (5.73, 4.54, 2.29, and 1.34 for 1960, 1970, 1980, and 1999, respectively)

Table 7-2 Racial and socioeconomic characteristics of aggregated census tracts within and beyond 1.0 mile from brownfields from 1960 to 2000 by using the areal apportionment method

	Census Tracts within 1.0 mile radius from brownfields					Census Tracts beyond 1.0 mile radius from brownfields				
	1960	1970	1980	1990	2000	1960	1970	1980	1990	2000
% White	78.9%	72.1%	62.4%	57.0%	52.5%	96.0%	96.4%	93.0%	90.5%	85.5%
% African American	20.9%	27.4%	35.8%	40.4%	43.2%	2.8%	3.2%	5.4%	7.0%	9.9%
Average Family Income[a]	$41,786	$55,791	$54,577	$52,195	$59,177	$50,518	$70,377	$73,334	$77,686	$86,090
Average Housing Values[a]	$76,724	$89,573	$86,976	$78,878	$120,348	$91,107	$118,653	$142,657	$138,639	$196,153
% Unemployed Persons	8.1%	6.4%	14.2%	12.6%	8.6%	6.8%	4.5%	8.9%	5.8%	4.1%
% Persons without High School Diplomas	62.8%	52.8%	39.3%	30.7%	23.6%	51.0%	39.6%	25.7%	18.5%	13.4%
% Vacant Housing Units	6.4%	4.7%	6.1%	6.6%	7.1%	6.0%	2.8%	3.5%	4.3%	4.0%
% Owner-Occupied Housing Units	64.7%	67.9%	64.3%	61.6%	64.1%	85.0%	82.0%	78.6%	76.3%	78.1%

[a] Adjusted in 1999 Dollar Value (5.73, 4.54, 2.29, and 1.34 for 1960, 1970, 1980, and 1999, respectively)

Table 7-3 Racial and socioeconomic characteristics of aggregated census tracts within and beyond 1.0 mile from brownfields from 1960 to 2000 by using the areal apportionment method (divided by Detroit and suburbs)

City of Detroit

	Census Tracts within 1.0 mile radius from brownfields					Census Tracts beyond 1.0 mile radius from brownfields				
	1960	1970	1980	1990	2000	1960	1970	1980	1990	2000
% White	68.6%	53.3%	32.1%	19.2%	12.3%	90.8%	78.1%	52.9%	35.3%	17.2%
% African American	31.3%	86.4%	65.8%	78.1%	83.5%	7.4%	27.5%	45.5%	62.4%	79.3%
Average Family Income[a]	$38,792	$49,161	$43,679	$37,466	$44,543	$49,185	$58,320	$52,493	$47,197	$51,742
Average Housing Values[a]	$70,999	$71,970	$51,584	$37,413	$69,551	$83,823	$83,395	$62,728	$45,015	$83,402
% Unemployed Persons	10.3%	7.4%	19.1%	20.7%	14.4%	6.1%	5.1%	14.5%	14.1%	11.0%
% Persons without High School Diplomas	66.8%	59.0%	46.9%	39.0%	31.3%	54.9%	49.2%	37.3%	30.3%	24.5%
% Vacant Housing Units	7.3%	6.3%	8.5%	9.2%	10.8%	3.4%	2.7%	4.4%	5.7%	6.6%
% Owner-Occupied Housing Units	55.9%	60.0%	55.7%	50.9%	52.8%	79.2%	77.4%	73.6%	66.6%	67.8%

Suburbs

	Census Tracts within 1.0 mile radius from brownfields					Census Tracts beyond 1.0 mile radius from brownfields				
	1960	1970	1980	1990	2000	1960	1970	1980	1990	2000
% White	94.2%	92.4%	90.1%	87.9%	82.8%	96.8%	98.4%	96.4%	94.5%	89.8%
% African American	5.4%	7.2%	8.3%	9.7%	12.8%	2.1%	1.3%	2.0%	3.0%	5.6%
Average Family Income[a]	$46,277	$62,786	$63,603	$62,909	$68,969	$50,742	$71,742	$75,011	$79,703	$88,029
Average Housing Values[a]	$82,873	$103,683	$111,320	$101,074	$144,287	$92,283	$122,635	$149,539	$144,494	$201,979
% Unemployed Persons	6.4%	5.3%	10.5%	7.4%	5.1%	5.3%	4.5%	8.5%	5.3%	3.7%
% Persons without High School Diplomas	56.2%	45.6%	32.6%	24.6%	18.5%	50.4%	38.4%	24.7%	17.7%	12.8%
% Vacant Housing Units	5.0%	2.8%	3.7%	4.5%	4.5%	6.5%	2.8%	3.4%	4.2%	3.8%
% Owner-Occupied Housing Units	79.4%	77.4%	72.4%	69.9%	71.6%	86.0%	82.6%	79.0%	77.0%	78.7%

[a] Adjusted in 1999 Dollar Value (5.73, 4.54, 2.29, and 1.34 for 1960, 1970, 1980, and 1999, respectively)

Table 7-4 Changes in numbers of persons by race from 1960 to 2000 by using the areal apportionment method

Tri-county area

	1960		1970		1980		1990		2000	
	Beyond	Within	Beyond	Within	Beyond	Within	Beyond	Within	Beyond	Within
White	1,208,316	1,975,566	1,584,004	1,808,775	1,716,197	1,372,218	1,746,376	1,131,373	1,829,682	1,000,118
Black	35,346	523,444	53,334	687,324	98,843	786,872	134,299	801,905	211,722	821,997

Detroit

	1960		1970		1980		1990		2000	
	Beyond	Within	Beyond	Within	Beyond	Within	Beyond	Within	Beyond	Within
White	153,940	1,029,019	124,431	694,487	75,257	338,038	45,482	170,818	21,653	100,483
Black	12,633	469,592	34,195	599,987	64,711	692,075	80,446	695,843	99,870	682,587

Suburbs

	1960		1970		1980		1990		2000	
	Beyond	Within	Beyond	Within	Beyond	Within	Beyond	Within	Beyond	Within
White	1,054,376	946,547	1,459,572	1,114,289	1,640,940	1,034,180	1,700,893	960,556	1,808,028	899,636
Black	22,713	53,852	19,139	87,337	34,131	94,798	53,853	106,062	111,852	139,410

Table 7-5 Differences in percentage changes[a] in racial and socioeconomic characteristics of areas within 1.0 radius from brownfields and from random points from 1960 to 2000 by employing the areal apportionment method

	1960 – 1970 (a)				1970 – 1980 (b)			
	BF[b]	RP[c]	DIF[d]	Sig	BF[b]	RP[c]	DIF[d]	Sig
% White	-14.23%	-0.37%	-13.86%	***	-22.58%	-4.68%	-17.90%	***
Average Family Income[a]	34.11%	43.86%	-9.75%	***	-4.70%	8.37%	-13.07%	***
Average Housing Values[a]	14.16%	38.17%	-24.00%	***	-4.03%	27.16%	-31.19%	***
% Unemployed Persons	-9.69%	12.73%	-22.42%	***	134.28%	87.87%	46.41%	***
% Persons without High School Diploma	-16.15%	-24.77%	8.62%	***	-24.87%	-37.62%	12.75%	***
% Vacant Housing Units	-29.11%	-49.96%	20.86%	***	60.34%	41.90%	18.44%	**
% Owner-Occupied Housing Units	32.51%	0.42%	32.08%	**	-12.27%	-2.48%	-9.79%	***
N	355	355			355	355		

	1980 – 1990 (c)				1990 – 2000 (d)			
	BF[b]	RP[c]	DIF[d]	Sig	BF[b]	RP[c]	DIF[d]	Sig
Percent of White	-22.33%	-4.95%	-17.38%	***	-12.36%	-7.30%	-5.06%	**
Average Family Income[a]	-7.12%	4.09%	-11.21%	***	16.21%	14.06%	2.15%	*
Average Housing Values[a]	-17.97%	-9.28%	-8.68%	***	63.88%	49.92%	13.96%	***
Percent of Unemployed Persons	-9.86%	-32.64%	22.78%	***	-29.29%	-29.86%	0.57%	
Percent of Persons without High School Diploma	-21.13%	-29.62%	8.49%	***	-22.55%	-27.54%	4.99%	***
Percent of Vacant Housing Units	20.10%	19.67%	0.43%		17.05%	7.57%	9.49%	**
Percent of Owner-Occupied Housing Units	-3.64%	-1.73%	-1.91%	*	3.85%	2.82%	1.03%	*
N	355	355			355	355		

* p > 0.05 ** p > 0.01 *** p > 0.001

[a] The percentage change is a ratio of change between two time periods (i.e., the percentage difference in % whites between 1960 and 1970 = [% White in 1970 –% White in 1960] / % White in 1960)

[b] Adjusted by 1999 dollar value (5.73, 4,54, 2.29, 1.34 for 1959, 1969, 1979, and 1989 dollar, respectively)

[c] BF = brownfield

[d] RP = random points

[e] DIF = Difference between Brownfield and Random points (Values of brownfield – Values of random points)

Figure 7-1 Change in average family income in constant 1999 dollars of neighborhoods within and beyond a 1.0 radius from brownfields from 1960 to 2000 using the areal apportionment method

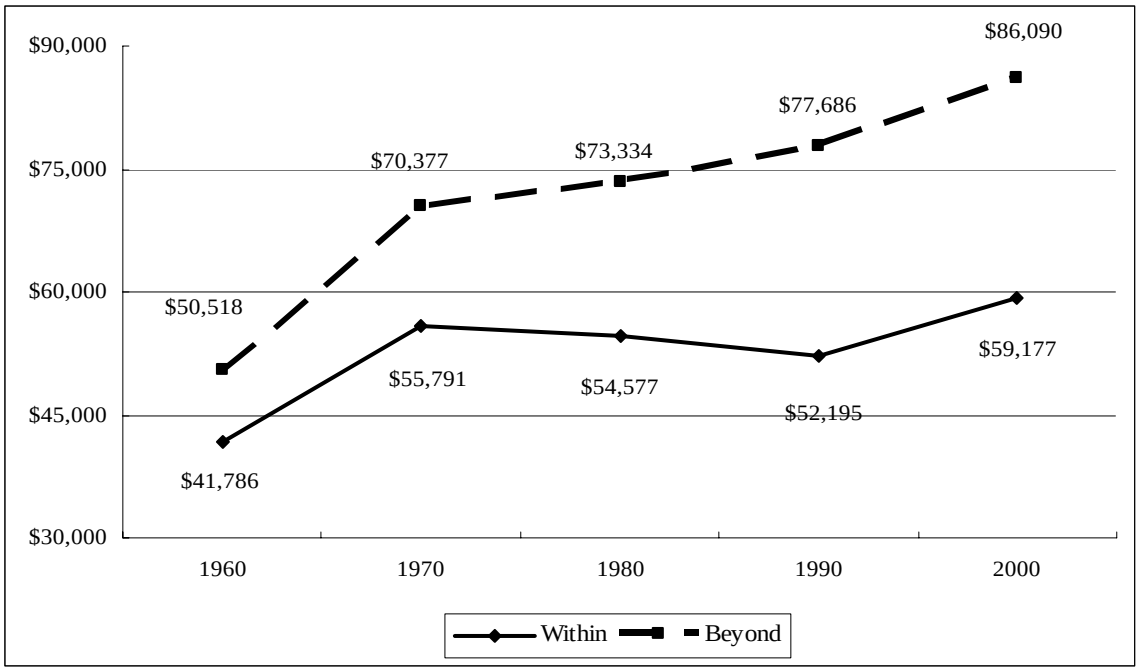


Figure 7-2 Change in average housing values in constant 1999 dollars of neighborhoods within and beyond a 1.0 radius from brownfields from 1960 to 2000 using the areal apportionment method

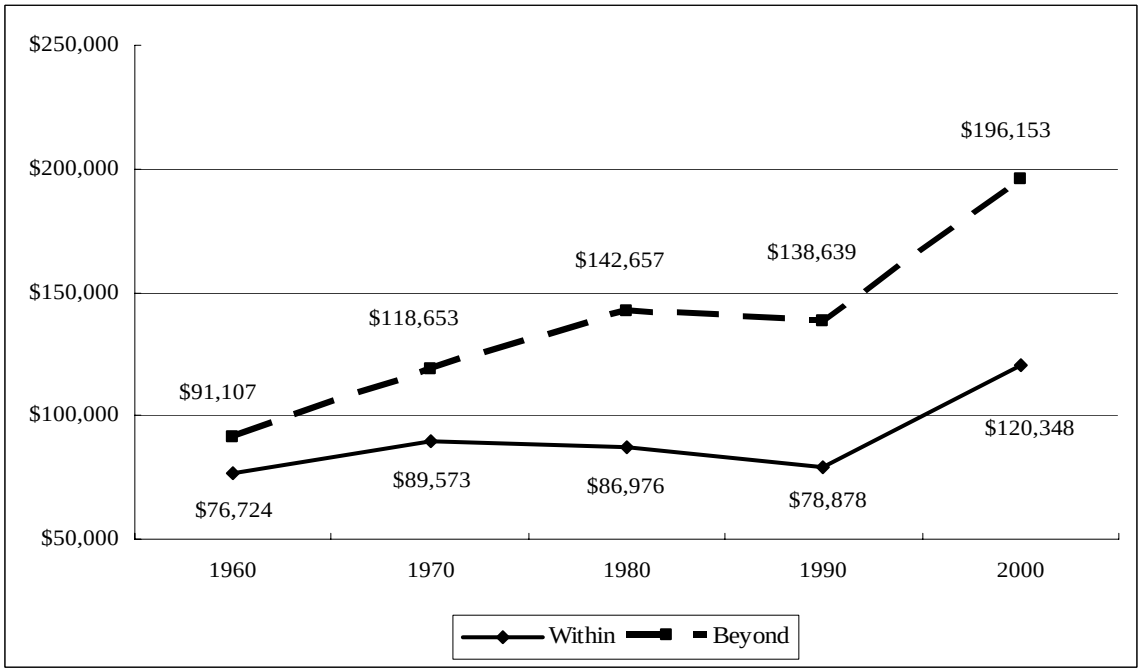


Figure 7-3 Change in the percent of unemployed persons of neighborhoods within and beyond a 1.0 radius from brownfields from 1960 to 2000 using the areal apportionment method

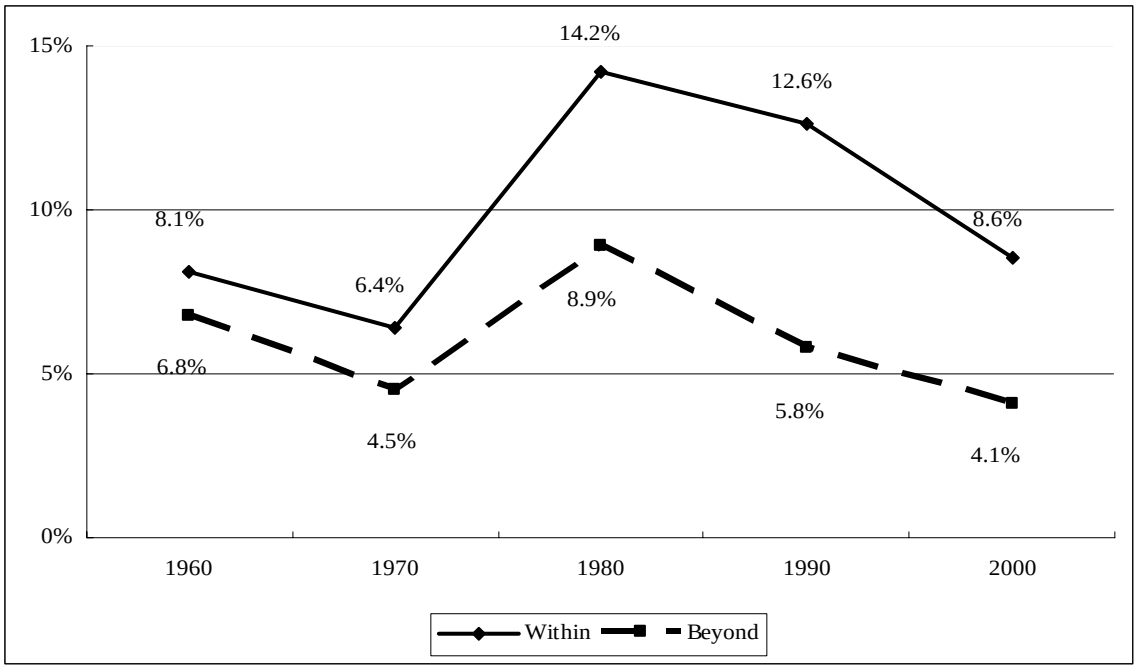


Figure 7-4 Mean percentage difference in average family income in constant 1999 dollars of areas within 1.0 mile radius from brownfields and random points from 1960 to 2000

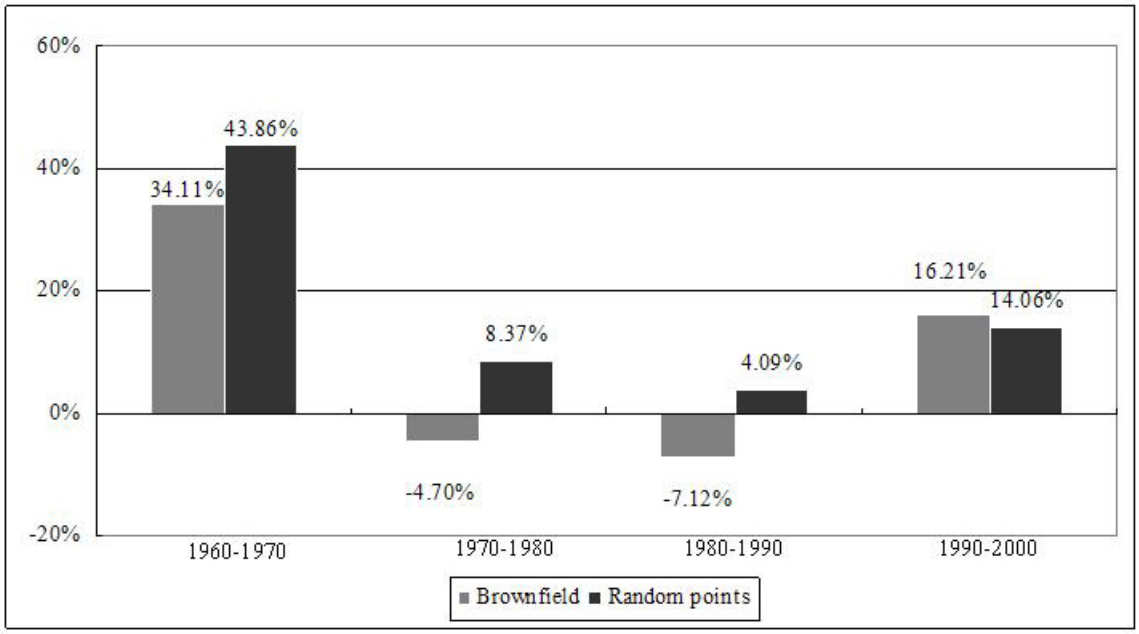


Figure 7-5 Mean percentage difference in average housing values in constant 1999 dollars of areas within 1.0 mile radius from brownfields and random points from 1960 to 2000

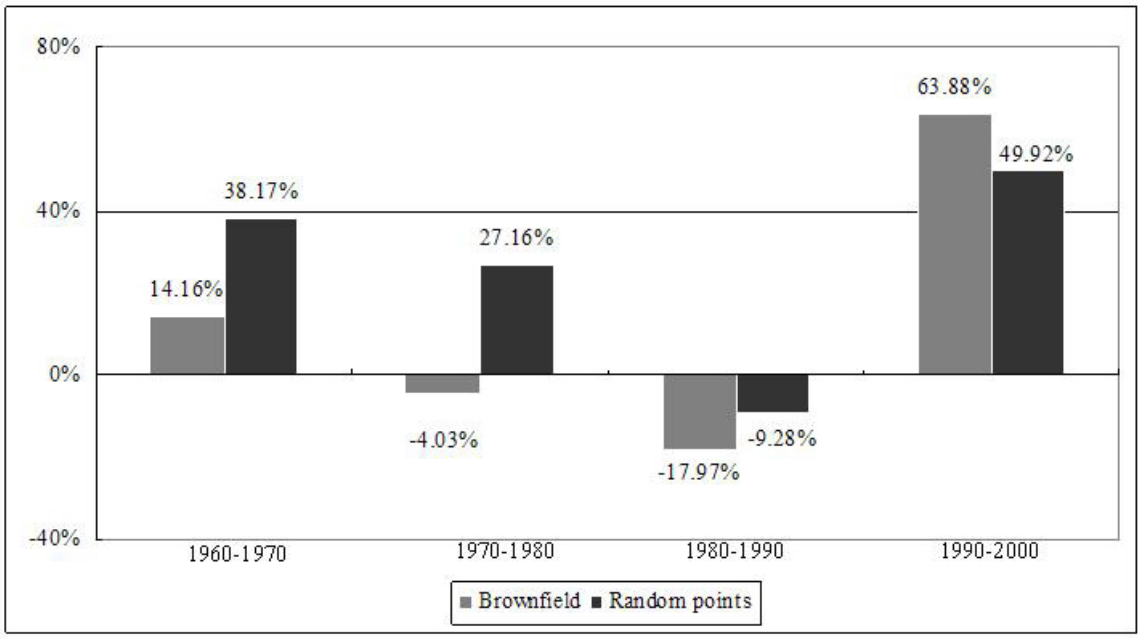
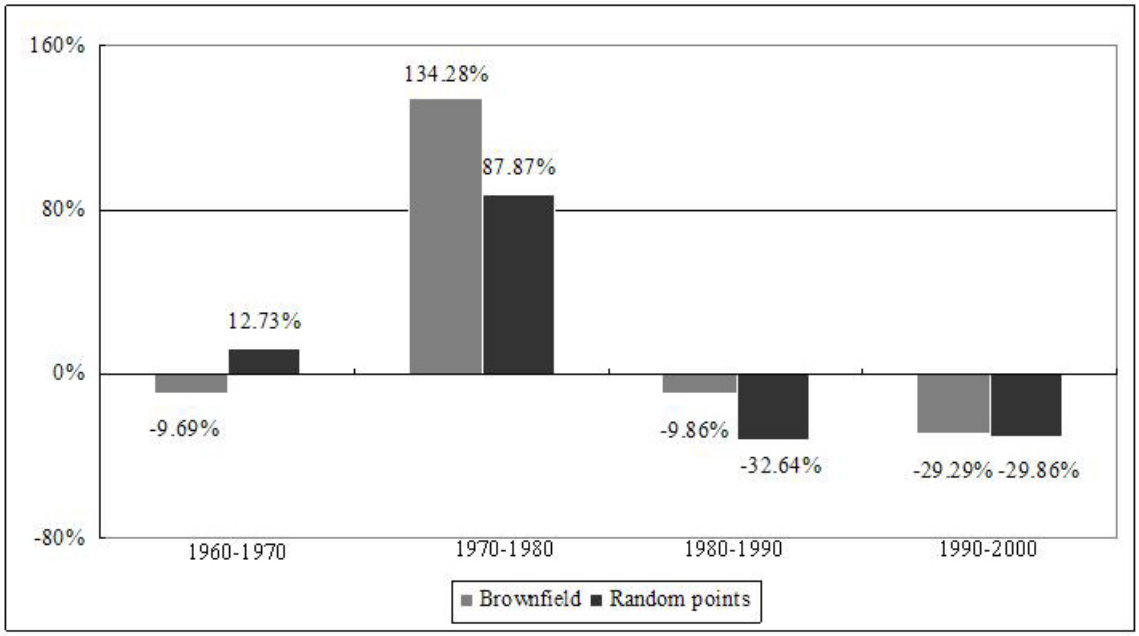


Figure 7-6 Mean percentage difference in unemployed persons of areas within 1.0 mile radius from brownfields and random points from 1960 to 2000



CHAPTER 8: LONGITUDINAL ASSESSMENT OF CHANGES IN RACIAL AND SOCIOECONOMIC CHARACTERISTICS IN BROWNFIELD AND NON-BROWNFIELD NEIGHBORHOODS FROM 1970 TO 2000 CONTROLLING FOR THE 1970 CONDITIONS

The previous chapter examined the racial and socioeconomic conditions of neighborhoods within and beyond a 1.0 mile radius from brownfields and found that neighborhoods within a 1.0 mile radius (brownfield neighborhoods) experienced greater socioeconomic decline after 1970 than did neighborhoods beyond a 1.0 mile radius (non-brownfield neighborhoods). This finding suggests that the deindustrialization that took place between 1960 and 1970 did not adversely affect the socioeconomic conditions of brownfield neighborhoods in the 1960s, but the impacts of deindustrialization on socioeconomic conditions of brownfield neighborhoods were observed in later decades. However, some might still argue that the decline in socioeconomic conditions that was greater in brownfield than in non-brownfield neighborhoods might have resulted from pre-existing socioeconomic differences between the two neighborhood groups. That is, because brownfield neighborhoods were more socioeconomically disadvantaged than non-brownfield neighborhoods as early as 1960, it is not clear whether brownfield neighborhoods would have experienced a greater socioeconomic decline than would have non-brownfield neighborhoods if these neighborhoods had shared similar socioeconomic characteristics in the initial time period.

To answer this question, the pre-existing socioeconomic differences between the two neighborhood groups need to be controlled. Ideally, the socioeconomic conditions in 1960 should be controlled when making the claim that the presence of brownfields in proximity to neighborhoods is associated with the decline in socioeconomic characteristics of those neighborhoods. Due to inconsistent census boundaries, however, controlling for the socioeconomic characteristics in 1960 was not feasible. Rather, socioeconomic characteristics in 1970 were controlled in order to more accurately examine whether the presence of brownfields is associated with socioeconomic decline in

nearby neighborhoods. Therefore, the objective for this chapter is to determine whether brownfield neighborhoods experienced greater socioeconomic decline than did non-brownfield neighborhoods after 1970, even when brownfield and non-brownfield neighborhoods shared similar socioeconomic conditions in 1970.

8-1 Data and Method

The units of analysis in this chapter are the 1970, 1980, 1990, and 2000 census tracts. The census tracts of 1970, 1980, and 1990 were normalized to 2000 census tracts by Geolytic, Inc. (see chapter 5 for detailed discussion of these data). As discussed in chapter 5, the 50% areal containment method is used when brownfield and non-brownfield neighborhoods are examined in this chapter. The 50% areal containment method averages socioeconomic characteristics for census tracts at least 50% of whose areas are captured by 1.0 mile circular buffers from brownfields, with these census tracts representing brownfield neighborhoods. The socioeconomic characteristics of census tracts less than 50% of whose areas are captured by 1.0 mile circular buffers from brownfields were also averaged, with these census tracts representing non-brownfield neighborhoods. Cluster analysis was performed based on 1970 socioeconomic characteristics to sort census tracts into several categories, each of whose 1970 socioeconomic characteristics were similar. That is, pre-existing socioeconomic differences between brownfield and non-brownfield neighborhoods in 1970 were minimized by use of cluster analysis (see chapter 5 for detailed discussion on cluster analysis).

The dependent variable in this chapter is whether neighborhoods are located within or beyond a 1.0 mile radius from brownfields. The independent variables are racial, socioeconomic, sociopolitical, and housing variables (see Appendix C for detailed information with respect to the construction of these variables). To ensure consistent monetary values between periods, average household income and average values for owner-occupied housing units of 1959, 1969, 1979, and 1989 are adjusted to 1999 dollars using a consumer price index inflation calculator[1]. The inflation ratios of 1959, 1969, 1979, and 1989 to 1999 dollars were 5.73, 4.54, 2.29, and 1.34, respectively.

In terms of statistical methods, changes in racial and socioeconomic characteristics

[1] The web-based calculator is available at http://www.bls.gov/cpi/.

between brownfield and non-brownfield neighborhoods are compared for each group of census tracts extracted from cluster analysis. For statistical testing, bi-variate correlation analysis is performed separately for each group. For multivariate analysis, partial correlation analyses were performed for each cluster to determine which variables were independent associated with the presence of brownfields near neighborhoods.

When statistical tests are employed, the dependent variable is whether or not at least 50% of the area in census tracts is captured by 1.0 mile circular buffers from brownfields; 1=yes and 0=no. Independent variables are the changes by decade between 1970 and 2000 in racial and socioeconomic characteristics discussed in the previous section. Computing changes in racial and socioeconomic characteristics between two time periods is accomplished in two ways. First, the simple difference between two periods is taken. This means that values of the earlier time period are subtracted from values of the later time period. For example, if the change in percent of African Americans between 1970 and 1980 is desired, the percent in 1970 is simply subtracted from the percent in 1980. Second, changes can be computed on the basis of ratio of change, meaning that the difference in a value between two periods is divided by a value in the earlier time period. For instance, to compute the percentage change as a ratio in average household income between 1970 and 1980, the income in 1970 is subtracted from the income in 1980, and then the subtracted value is divided by the income in 1970.

In this chapter, changes refer to percentage change as a ratio, such as for average household income and average values for owner-occupied housing units. For the other variables, changes refer to simple value differences between two periods. Ideally, a consistent method should be employed to avoid confusion. However, the percentage changes as a ratio for many racial and socioeconomic characteristics prove virtually impossible to compute because many census tracts in 1970 have 0% of some racial or socioeconomic characteristics such as percent of African Americans, percent of Hispanics, percent of female-headed families with dependent children, and percent of household receiving public assistance. Because 0% in the denominator generates a statistical error when percentage differences are calculated, it is impossible to compute the percentage changes as a ratio between two periods for those variables. Thus, different methods are used to calculate percent racial and percent socioeconomic changes between periods.

8-2 Results

First, the socioeconomic characteristics of four clusters extracted by means of cluster analysis are presented. Census tracts belonging to the same cluster represent the minimal variation of socioeconomic characteristics among the tracts. Census tracts belonging to different clusters mean that the variation of socioeconomic characteristics across the clusters is maximized. The clusters thus represent grouping of census tracts with similar socioeconomic characteristics, the four group ranging from relatively affluent to relative poor clusters of census tracts. Then simple descriptive statistics with respect to changes in racial and socioeconomic characteristics between brownfield and non-brownfield neighborhoods within each cluster from 1970 to 2000 are shown. Correlation matrices by cluster are presented, followed by the results from logistic regression from 1970 to 2000.

8-2-1 Descriptive Statistics

Table 8-1 shows the socioeconomic characteristics of four groups extracted by means of cluster analysis. Among 1144 census tracts in the study area, 115 (10%) and 328 (29%) belong to clusters 1 and 2, respectively, while 561 (49%) and 140 (12%) belong to clusters 3 and 4, respectively (see Figure 8-1 for geographical locations of clusters 1-4 census tracts). In going from cluster 1 to cluster 4, socioeconomic conditions tend to decline: cluster 1 census tracts represent the highest socioeconomic conditions followed by clusters 2 and 3 census tracts, while cluster 4 census tracts represent the most socioeconomically disadvantaged neighborhoods. For example, average household income for cluster 1 census tracts in 1970 was more than $23,000 while household incomes for cluster 2, cluster 3, and cluster 4 census tracts in the same year were $14,595, $11,612, and $8,071, respectively (see Table 8-1). The percent of unemployed persons in cluster 1 census tracts in 1970 was approximately 3%, while the percent in 1970 were 4%, 6%, and 10% when moving to clusters 2, 3, and 4 census tracts, respectively. Other characteristics evince the same pattern. Racial variables were not included in performing the cluster analysis. However, they exhibit an interesting pattern, with minority persons tending to concentrate in cluster 4 census tracts (69% were minorities) the tracts with the worst socioeconomic conditions; on the other hand, more than 90% of persons in the more affluent clusters of census tracts in 1970 were whites

(see Table 8-1).

Before discussing racial and socioeconomic conditions between brownfield and non-brownfield neighborhoods by cluster by decade, it should be noted that the tables and figures shown in this chapter are limited to using 1.0 mile circular buffers from brownfields for clusters 1, 2, and 3 census tracts. For cluster 4 census tracts, tables and figures are limited to using 0.5 mile circular buffers from brownfields. Analyses of changes in racial and socioeconomic characteristics from 1970 to 2000 using 0.5 mile circular buffers from brownfields for clusters 1, 2, and 3 census tracts are not discussed for the following reasons. First, only 7 out of the 115 cluster 1 census tracts were brownfield neighborhoods, which is an insufficient number for yielding meaningful conclusions. Second, when employing 0.5 mile circular buffers from brownfields in clusters 2 and 3 census tracts, similar patterns emerged using 1.0 mile circular buffers from brownfields. In terms of cluster 4 census tracts, only 8 out of the 140 cluster 4 census tracts were non-brownfield neighborhoods when a 1.0 mile radius is applied, which is an insufficient number for yielding meaningful conclusions. Therefore, results using a 0.5 mile radius from brownfields are presented for cluster 4 census tracts in this section. However, for comparison, results of analyses using a 0.5 mile radius for clusters 1, 2, and 3 census tracts and using a 1.0 mile radius for cluster 4 census tracts are presented in Appendices I-T. The pattern of results reported in Appendices I-T are similar to those reported in tables in this chapter.

Tables 8-2 and 8-3 show changes in socioeconomic characteristics in brownfield and non-brownfield neighborhoods in cluster 1 from 1970 to 2000. In general, both brownfield and non-brownfield neighborhoods experienced an increase in the proportion of minorities. Figure 8-2 provides a graphical illustration of changes in the percent of African Americans between brownfield and non-brownfield neighborhoods. However, the magnitude of change was greater for brownfield neighborhoods than for non-brownfield neighborhoods. For instance, the percent of whites in brownfield neighborhoods decreased from 98% in 1970 to 91% in 1980. Subsequently, the percent continued to decrease from 82% in 1990 to 75% in 2000 (see Table 8-2). On the other hand, the percent of whites in non-brownfield neighborhoods decreased from 99% in 1970 to 94%, 89%, and 81% in 1980, 1990, and 2000, respectively (see Table 8-3).

Brownfield neighborhoods experienced more rapid decline in socioeconomic conditions than did non-brownfield neighborhoods. For example, the average household income (see Figure 8-3 for graphic illustration of changes between brownfield and non-brownfield neighborhoods) in brownfield neighborhoods decreased from $98,000 in 1970 to $88,000 in 1980 (see Table 8-2). Yet average household income in non-brownfield neighborhoods was stable in the same period (see Table 8-3). Although both brownfield and non-brownfield neighborhoods experienced an increase in average household income from 1980 to 1990, 10.9% ($109,000 in 1980 to $120,000 in 1990) and 6.8% ($88,000 in 1980 to $94,000 in 1990) of the increases in income for non-brownfield and brownfield neighborhoods, respectively, are found in this period. During the 1990s, average household income slightly decreased ($94,000 in 1990 to $92,000 in 2000) in brownfield neighborhoods (see Table 8-2) but increased slightly ($120,000 in 1990 to $121,000 in 2000) in non-brownfield neighborhoods (see Table 8-3). The gap in average household income between brownfield and non-brownfield neighborhoods grew from $10,000 in 1970 to $30,000 in 2000 (see Figure 8-3).

The average values for owner-occupied housing units between brownfield and non-brownfield neighborhoods share the same pattern of change. For example, both brownfield and non-brownfield neighborhoods experienced an increase in the average values between 1970 and 1980, and then the average values decreased between 1980 and 1990 for both neighborhoods. Finally, average values began increasing between 1990 and 2000 for both neighborhoods (see Figure 8-4). When the magnitude of difference by decade is probed, non-brownfield neighborhoods enjoyed greater improvement in average values. For example, brownfield neighborhoods experienced a 12% increase ($178,000 in 1970 to $200,000 in 1980) and a 4% decrease ($200,000 in 1980 to $192,000 in 1990) in the average values in the 1970s and 1980s, respectively (see Table 8-2), while a 30% increase ($199,000 in 1970 to $258,000 in 1980) and a 0.7% decrease in the average values were observed for non-brownfield neighborhoods in 1970s and 1980s, respectively (see Table 8-3). From 1990 and 2000, brownfield neighborhoods evinced greater increase in the average values than did non-brownfield neighborhoods. While brownfield neighborhoods experienced a 36% increase ($192,000 in 1990 to $261,000 in 2000) in the average values (see Table 8-2), a 28% increase ($256,000 in

1990 to $328,000) in the average values for non-brownfield neighborhoods was experienced (see Table 8-3). Due to the magnitude of differences between brownfield and non-brownfield neighborhoods, the gap in the average values between brownfield and non-brownfield neighborhoods grew from $21,000 in 1970 to $67,000 in 2000 (see Figure 8-4). Other variables also show similar patterns (see Table 8-2 and 8-3).

For cluster 2 census tracts, brownfield neighborhoods similarly show a greater increase in percent of African Americans than do non-brownfield neighborhoods (see Figure 8-5 for graphical illustration of changes between brownfield and non-brownfield neighborhoods). The percent of African Americans in brownfield neighborhoods grew from 3% in 1970 to 27% in 2000 (see Table 8-4), while the percent in non-brownfield neighborhoods increased from 1% in 1970 to 11% in 2000 (see Table 8-5). Further, a greater decline in socioeconomic conditions in brownfield than in non-brownfield neighborhoods becomes evident. Brownfield neighborhoods, for instance, experienced continuous decline in average household income from 1970 to 1990, but the income in non-brownfield neighborhoods increased during the same time period. From 1990 to 2000, both neighborhoods experienced increased the income (see Figure 8-6). Specifically, the average household income in brownfield neighborhoods decreased from $65,000 in 1970 to $61,000 and $59,000 in 1980 and 1990, respectively (see Table 8-4). On the other hand, the average income in non-brownfield neighborhoods had been stable from $67,000 in 1970 to $68,000 in 1980 and 1990 (see Table 8-5). Differences in average household income between brownfield and non-brownfield neighborhoods grew from $2,000 in 1970 to $10,000 in 2000 (see Figure 8-6).

As with cluster 1 census tracts, average values for owner-occupied housing units for cluster 2 census tracts share the same pattern of change between brownfield and non-brownfield neighborhoods (see Figure 8-7). Similarly to cluster 1 census tracts, non-brownfield neighborhoods show greater improvement in the average values. For instance, a 9% increase ($110,000 in 1970 to $120,000 in 1980) and a 21% decrease ($120,000 in 1980 to $95,000 in 1990) in the average values were observed in the 1970s and 1980s, respectively (see Table 8-4). In contrast, non-brownfield neighborhoods experienced a 27% increase ($116,000 in 1970 to $147,000 in 1980) and an 18% decrease ($147,000 in 1980 to $121,000 in 1990) in the average values in the 1970s and

1980s, respectively (see Table 8-5). During the 1990s, a 45% increase ($95,000 in 1990 to $138,000 in 2000) for brownfield neighborhoods and a 40% increase ($121,000 in 1990 to $169,000 in 2000) for non-brownfield neighborhoods in the average values were experienced. Differences in the average values between brownfield and non-brownfield neighborhoods grew from $6,000 in 1970 to $31,000 in 2000 (see Figure 8-7).

Percent of unemployed persons shows an interesting pattern. The percent in brownfield neighborhoods was even lower than the percent in non-brownfield neighborhoods in 1970. However, this trend reversed in 1980, meaning that the percent in non-brownfield neighborhoods became lower than the percent in brownfield neighborhoods in 1980. This pattern remained unchanged for remaining decades. Still, other socioeconomic characteristics indicate that brownfield neighborhoods had experienced a greater decline than had non-brownfield neighborhoods (see Table 8-4 and 8-5).

For cluster 3 census tracts, as before for clusters 1 and 2 census tracts, brownfield neighborhoods show a greater increase in percent of African Americans than do non-brownfield neighborhoods (see Figure 8-8 for graphical illustration of changes between brownfield and non-brownfield neighborhoods). The percent of African Americans in brownfield neighborhoods grew from 10% in 1970 to 40% in 2000 (see Table 8-4), while the percent in non-brownfield neighborhoods increased from 2% in 1970 to 8% in 2000 (see Table 8-5). Cluster 3 census tracts reveal that 8% difference in the percent of African Americans in 1970 was found, and the difference in 2000 grew to 32% between brownfield and non-brownfield neighborhoods. Socioeconomic differences between brownfield and non-brownfield widened from 1970 to 2000. For example, the average household income for brownfield neighborhoods decreased between 1970 and 1980, stabilizing in the 1980s and increasing between 1990 and 2000 (see Figure 8-5). On the other hand, the income for non-brownfield neighborhoods increased between 1970 and 1980 but decreased in the 1980s, continuing on to show income growth between 1990 and 2000 (see Figure 8-9). The gap in the income widened from $4,000 in 1970 to $19,000 in 2000 (see Table 8-6 and Table 8-7).

In terms of average values of owner-occupied housing units, the pattern of change between brownfield and non-brownfield neighborhoods resembles changes in average

household income. Between 1970 and 1980, brownfield neighborhoods lost while non-brownfield neighborhoods gained in the average values. Both neighborhoods lost and gained in the average values in the 1980s and 1990s, respectively (see Figure 8-10). As with average household income, the gap in the average values widened from $18,000 in 1970 to $75,000 in 2000 (see Table 8-6 and Table 8-7). Other variables indicate that the socioeconomic gap between brownfield and non-brownfield neighborhoods widened from 1970 to 2000.

In contrast to clusters 1, 2, and 3, the pattern of racial and socioeconomic changes between brownfield and non-brownfield neighborhoods for cluster 4 census tracts were very similar. Both brownfield and non-brownfield neighborhoods experienced similar growth ratios of the percent of African Americans (see Figure 8-11 for graphical illustration of changes between brownfield and non-brownfield neighborhoods). For example, while brownfield neighborhoods experienced a 21% increase in the percent of African Americans between 1970 (71%) and 2000 (86%), non-brownfield neighborhoods experienced a 19% increase in this percent for the same time period (62% in 1970 and 74% in 2000) (see Table 8-8 and Table 8-9). Average household income reveals a similar pattern (see Figure 8-12 for graphical illustration of changes between brownfield and non-brownfield neighborhoods). Whereas brownfield neighborhoods experienced an 8% decline in average household income between 1970 ($36,300) and 2000 ($33,740), non-brownfield neighborhoods also experienced a 5% decrease in this income for the same time period ($37,440 in 1970 and $34,520 in 2000) (see Table 8-8 and Table 8-9). Finally, the average housing values for owner-occupied housing units share similar patterns (see Figure 8-13 for graphical illustration of changes between brownfield and non-brownfield neighborhoods).

Although the above results revealed that brownfield neighborhoods experienced higher increases of percent of African Americans than did non-brownfield neighborhoods, these results fail to reveal migration patterns of racial groups. For example, increases in percent of African Americans in brownfield neighborhoods could have resulted from loss of whites or gain in African Americans or loss of both whites and African Americans but faster rates of decrease for African Americans than whites and so on. Thus, in order to probe migratory patterns, changes in the number of persons in brownfield and non-

brownfield neighborhoods by race by cluster need to be investigated. Results indicate that whites moved out of brownfield neighborhoods but moved into non-brownfield neighborhoods. At the same time, African Americans moved into both brownfield and non-brownfield neighborhoods. Specifically, Table 8-10 (a) shows that for cluster 1 census tracts (the most affluent), non-brownfield neighborhoods experienced a 12% increase in the number of whites from 1970 (218,452) to 1990 (244,104), but these neighborhoods lost 6% of the white population from 244,104 in 1990 to 230,436 in 2000. The number of African Americans in these neighborhoods consistently grew from 767 in 1970 to 35,168 in 2000. On the other hand, brownfield neighborhoods experienced decline in the number of whites (105,801 to 78,476) and increase in the number of African Americans (1450 to 19,132) between 1970 and 2000. Table 8-10 (b) shows that for cluster 2 census tracts, both brownfield and non-brownfield neighborhoods experienced decline in the number of whites and increase in the number of African Americans from 1970 to 2000. However, while non-brownfield neighborhoods experienced only a 5% decline in the number of whites between 1970 and 2000, brownfield neighborhoods encountered a 32% decline in the number of whites in this period. At the same time, while non-brownfield neighborhoods experienced a 473% increase in the number of African Americans in this period, brownfield neighborhoods experienced a 606% increase. Table 8-10 (c) shows that for cluster 3 census tracts, while non-brownfield neighborhoods experienced a 44% increase in the number of whites from 677,979 in 1970 to 979,100 in 2000, brownfield neighborhoods encountered a 46% decrease in the number of whites from 1,032,207 in 1970 to 558,711 in 2000. Both brownfield and non-brownfield neighborhoods experienced 191% (138,142 in 1970 to 402,670 in 2000) and 341% (17,254 in 1970 to 76,113) increases, respectively, in the number of African Americans. Table 8-10 (d) shows that for cluster 4 census tracts (the most impoverished neighborhoods), brownfield neighborhoods experienced an 86% decline in the number of whites from 129,673 in 1970 to 18,713 in 2000 and a 49% decline in the number of African American populations from 383,708 in 1970 to 195,081 in 2000. Similarly, non-brownfield neighborhoods also encountered a 67% decline in the number of whites from 92,111 in 1970 to 30,033 in 2000 and a 47% decline in the number of African Americans from 152,180 in 1970 to 80,572 in 2000.

In conclusion, descriptive statistics show that the differences in socioeconomic characteristics between brownfield and non-brownfield neighborhoods widened after 1970 despite sharing similar socioeconomic characteristics in 1970 for clusters 1, 2, and 3 census tracts. In addition, brownfield neighborhoods lost whites from 1970 to 2000 while non-brownfield neighborhoods gained whites in this period. However, differences between brownfield and non-brownfield neighborhoods for cluster 4 census tracts, representing the most impoverished neighborhoods in 1970, remained relatively constant between 1970 and 2000. Because neighborhoods in cluster 4 were extremely impoverished with high concentration of minorities in 1970, there might have been little room for further socioeconomic declines in brownfield neighborhoods relative to non-brownfield neighborhoods. Furthermore, the extremely impoverished conditions in non-brownfield neighborhoods may have prevented them from attracting new investments that might have stimulated neighborhood improvement. However, pinning down the precise reasons is beyond the scope of the data and represents an interesting and important focus for future research.

8-2-2 Bi-vriate Analysis

Correlation analysis was performed to test the statistical significance of racial and socioeconomic changes between brownfield and non-brownfield neighborhoods. Census tracts are coded as zero if less than 50% of their areas are captured by 1.0 mile circular buffers from brownfields, while census tracts are coded as one if 50% or more of their areas are captured by 1.0 mile circular buffers from brownfields. For cluster 1 census tracts, brownfield neighborhoods experienced statistically significant socioeconomic decline between 1970 and 1980. Difference in change in percent of female-headed families with dependent children, and in change in percent of persons over 16 occupied in blue collar occupations between 1970 and 1980 are statistically significant between brownfield and non-brownfields (see Table 8-11 (a)). Specifically, brownfield neighborhoods gained a significantly greater percent of the above in this period than did non-brownfield neighborhoods. On the other hand, differences in change in the percent of persons over 25 having a bachelor's degree, in change in persons over 16 employed by white collar occupations, and in change in owner-occupied housing units between 1970 and 1980 are statistically significant between brownfield and non-brownfields (see Table

8-11 (a)). Non-brownfields gained a significantly greater percent of the above in this period than did brownfield neighborhoods.

Finally, differences in percentage changes in average household income and in average values for owner-occupied housing units from 1970 to 1980 between brownfield and non-brownfield neighborhoods are statistically significant (see Table 8-11 (a)). For the difference in percentage changes in average household income, non-brownfield neighborhoods experienced a significantly higher percentage of increases in this variable than did brownfield neighborhoods in this period. For the difference in changes in average values for owner-occupied housing units, however, brownfield neighborhoods experienced a significantly higher percentage of increases in this variable than did non-brownfield neighborhoods in this period. After 1980, there is no significant difference in socioeconomic change from 1980 to 2000 between brownfield and non-brownfield neighborhoods except for the percentage increase in average values for owner-occupied housing units between 1990 and 2000 (see Table 8-11 (c)). Brownfield neighborhoods experienced a greater percentage increase in the average values than non-brownfield neighborhoods in this period, which can be explained by the unusual growth of national economic prosperity in the 1990s (Jargowsky 2003).

Brownfield neighborhoods in cluster 2 census tracts experienced a greater decline in socioeconomic conditions and greater increase in percent of African Americans between 1970 and 1980 than did non-brownfield neighborhoods. All except three variables are statistically significant, and the three insignificant variables are (1) change in the percent of Hispanics, (2) change in the percent of vacant housing units, and (3) change in the percent of owner-occupied housing units between 1970 and 1980 (see Table 8-11 (d)). The directions of these variables are as expected. For example, brownfield neighborhoods experienced a significantly greater increase in percent of persons below the poverty line in this period than did non-brownfield neighborhoods. Differences in percentage changes in average household income and in average values for owner-occupied housing units from 1970 to 1980 between brownfield and non-brownfield neighborhoods are also statistically significant (see Table 8-11 (d)), and non-brownfield neighborhoods experienced significantly higher percentage increases in these variables than did brownfield neighborhoods in this period.

Between 1980 and 1990 socioeconomic characteristics declined to a greater extent in brownfield than in non-brownfield neighborhoods. Statistically significant variables are differences in (1) change in the percent of African Americans, (2) change in the percent of Hispanics, (3) change in the percent of female-headed families with dependent children, (4) change in the percent of persons below the poverty line, (5) change in average household income, (6) change in average values for owner-occupied housing units, and (7) change in the percent of persons over 16 employed in white collar occupations between 1980 and 1990 (see Table 8-11 (e)). When strength of associations was examined, socioeconomic declines in the 1980s became more weakly associated with brownfield neighborhoods compared to socioeconomic declines in the 1970s. For example, the Pearson correlation coefficient between changes in average household income and likelihood of the neighborhoods being near brownfields from 1970 and 1980 was -0.2402 (see Table 8-11 (d)), but this coefficient weakened to -0.1785 for the 1980 to 1990 period (see Table 8-11 (e)). The directions of the coefficients in Table 8-11 are as expected except for the change in percent of Hispanics between 1980 and 1990, meaning that non-brownfield neighborhoods gained a significantly greater percent of Hispanics between 1980 and 1990 than did brownfield neighborhoods. Because minorities tend to live in proximity to each other and there were few Hispanics in the study area, Hispanics could have moved in significant numbers into non-brownfield neighborhoods in this period. Finally, non-brownfield neighborhoods experienced a greater percentage increase in average values for owner-occupied housing units in this period than did brownfield neighborhoods (see Table 8-11 (e)).

Finally, as with cluster 1, brownfield neighborhoods experienced a greater degree of socioeconomic improvement between 1990 and 2000 than did non-brownfield neighborhoods. For example, non-brownfield neighborhoods experienced greater increase in the percent of persons below poverty between 1990 and 2000 than did brownfield neighborhoods (see Table 8-11 (f)), evidence that the level of poverty decreased in this period. The difference in percentage change in average values for owner-occupied housing units in this period between brownfield and non-brownfield neighborhoods is also statistically significant (see Table 8-11 (f)).

For cluster 3 census tracts, changes in all variables except for difference in change

in the percent of owner-occupied housing units from 1970 to 1980 between brownfield and non-brownfield neighborhoods are statistically significant (see Table 8-12 (a)). Their directions behave as expected except for the difference in change in percent of Hispanics, indicating that brownfield neighborhoods experienced greater socioeconomic decline than did non-brownfield neighborhoods in this period. Between 1980 and 1990, brownfield neighborhoods continued to decline to a greater degree in socioeconomic characteristics than did non-brownfield neighborhoods. All variables except for changes in average household income, change in percent of persons over 25 who do not have high school diplomas, and change in percent of persons over 16 employed in blue collar occupations in this period are statistically significantly associated, and in the expected direction, with whether or not neighborhoods are near brownfields (see Table 8-12 (b)). Strengths of the associations for statistically significant variables in the 1980-1990 period remained similar to those in the 1970-1980 period. For example, the Pearson correlation coefficient between change in percent below the poverty line and likelihood of the neighborhoods being near brownfields from 1970 to 1980 was 0.3937 (see Table 8-12 (a)), and increased only slightly from 1980 to 1990 to 0.4416 (see Table 8-12 (b)). The directions of the coefficients behave as expected except for the difference in change in percent of Hispanics. As with clusters 1 and 2 census tracts, brownfield neighborhoods gained greater socioeconomic improvement between 1990 and 2000 than did non-brownfield neighborhoods. For example, non-brownfield neighborhoods experienced greater increase in percent of persons below the poverty line than did brownfield neighborhoods (see Table 8-12 (c)).

For cluster 4 census tracts, changes for brownfield and non-brownfield neighborhoods are not statistically significant in almost all cases. There are two exceptions. The difference in change in percent of unemployed persons from 1970 to 1980 between brownfield and non-brownfield neighborhoods, for example, are statistically significant, and brownfield neighborhoods gained a greater increase in this percent than did non-brownfield neighborhoods (see Table 8-12 (d)). Between 1980 and 1990, the difference in change in percent of households receiving public assistance in this period between brownfield and non-brownfield neighborhoods are statistically significant, and brownfield neighborhoods gained a greater increase in this percent than did non-

brownfield neighborhoods (see Table 8-12 (e)). No other statistically significant changes for cluster 4 census tracts were found.

In conclusion, comparisons of patterns among the four clusters reveal an interesting trend. Each cluster exhibits a distinctly different pattern of socioeconomic changes. For cluster 1 census tracts (the most affluent), there was significant socioeconomic decline in brownfield neighborhoods relative to non-brownfield neighborhoods from 1970 to 1980. However, there were no significant differences in the pattern of changes between brownfield and non-brownfield neighborhoods after 1980. This finding indicates that brownfield neighborhoods in this cluster became stable after they experienced an initial socioeconomic shock in the 1970s. For clusters 2 census tracts (less affluent), brownfield neighborhoods relative to non-brownfield neighborhoods experienced continuous socioeconomic declines until 1990, but the degrees of socioeconomic declines in the 1980s were smaller than were the degrees of socioeconomic declines in the 1970s. In the 1990s, however, brownfield neighborhoods experienced a greater socioeconomic improvement than did non-brownfield neighborhoods. For cluster 3 census tracts (less affluent than cluster 2), brownfield neighborhoods relative to non-brownfield neighborhoods experienced continuous socioeconomic declines until 1990, and the degrees of socioeconomic declines in the 1980s remained similar compared to the degrees of socioeconomic declines in the 1970s. Like cluster 2 census tracts, brownfield neighborhoods in this cluster experienced a greater socioeconomic improvement than did non-brownfield neighborhoods between 1990 and 2000. For cluster 4 census tracts (the most impoverished), no significant differences in socioeconomic declines between brownfield and non-brownfield neighborhoods were observed.

Such distinctive patterns among clusters may be explained by different capacities of absorbing the initial socioeconomic shock from deindustrialization of the 1960s, and such capacities appear to be based on the initial socioeconomic conditions of neighborhoods. Wealthy neighborhoods (cluster 1) have likely had higher capacities to tolerate the initial socioeconomic shock so that their socioeconomic declines were confined to one decade after the shock. However, going to middle income neighborhoods (clusters 2 and 3), the initial shock appears to be associated with continuous socioeconomic decline in later

decades. In addition, brownfield neighborhoods experienced a significant socioeconomic improvement than did non-brownfield neighborhoods in the 1990s. This can be explained by unusual economic growth in this period. In other words, when the national economic is fast-growing, industries often reach to population segments who would not be hired under the slow-growing economic condition. Thus, it can be argued that many unemployed individuals in brownfield neighborhoods might have benefited from the unusual fast-growing national economy in the 1990s, which resulted in the above finding. For cluster 4 neighborhoods, these census tracts were the most impoverished in the beginning leaving little room for further racial and socioeconomic declines. However, validating these explanations is beyond the scope of the data, and such validation can be better accomplished in the future by in-depth historic examinations of brownfield and non-brownfield neighborhoods by cluster.

8-2-3 Multivariate analysis

Bi-variate analyses presented above do not answer the question of which variables are independently associated with the presence of brownfields from 1970 to 2000 since a number of them (e.g., changes in average household income and changes in percent of persons under the poverty line) are highly associated with each other. Therefore, a series of partial correlations was performed. Variables included in the partial correlation analyses involved only those that were statistically significant in the bi-variate correlation analyses (Table 8-11 and 8-12). Therefore, if a certain period did not contain multiple variables that were statistically significant, partial correlation analyses were not performed for these periods. For instance, because there were no multiple statistically significant variables in the 1980s and 1990s for cluster 1 census tracts and all periods for cluster 4 census tracts, partial correlations were not performed for clusters 1 and 4 for those time periods.

For cluster 1 census tracts, all variables lost their statistical significance in the 1970 to 1980 period when controlling for statistically significant variables (see Table 8-13(a)) possibly due to multicollinearity. For example, when bi-variate correlation matrices among variables are examined, a high correlation (0.628) between change in average household income and change in percent of owner-occupied housing units was found. When the change in percent of owner-occupied housing units is excluded, the partial

correlation between the presence of brownfields and change in average household income increases from 0.0520 to -0.1564, but it fails to reach the statistical significance level of 0.05. When the change in average household income is dropped, the partial correlation between the presence of brownfields and change in the percent of owner-occupied housing units, increased from -0.1572 to -0.2377, and it became statistically significant at the 0.05 level.

For cluster 2 census tracts, change in the percent of African Americans and change in average household income from 1970 to 1980 were independently associated with the presence of brownfields when controlling for statistically significant variables (see Table 8-13 (b)). Between 1980 and 1990, those two variables plus change in percent of Hispanics became independently associated with the presence of brownfields when controlling for statistically significant variables (see Table 8-13 (c)). In the 1990s, only change in percent of Hispanics was independently associated with brownfield locations when controlling for statistically significant variables (see Table 8-13 (d)). However, the direction of change in the percent of Hispanics is unexpected, meaning that as percent of Hispanics in a census tract increased in the 1980s and 1990s, this census tract was less likely to be located near brownfields.

For cluster 3 census tracts, five variables were independently associated with presence of brownfields from 1970 to 1980 when controlling for statistically significant variables, and they are changes in (1) percent of African Americans, (2) percent of Hispanics, (3) average household income, (4) percent of persons over 25 who do not have high school diplomas, and (5) percent of persons over 16 employed in blue collar occupations (see Table 8-13 (e)). Between 1980 and 1990, three variables – changes in percent of Hispanics, percent of persons below the poverty line, and average values for owner-occupied housing units – were independently associated with brownfield locations when controlling for statistically significant variables (see Table 8-13 (f)). Finally, five variables – (1) changes in percent of African Americans, (2) percent of Hispanics, (3) average values for owner-occupied housing units, (4) percent of persons over 25 having no high school diplomas, and (5) percent of persons over 25 having bachelor's degree or higher – became significantly and independently associated with the presence of brownfields in the 1990s when controlling for statistically significant variables (see Table

8-13 (g)). Like cluster 2 census tracts, the direction of change in the percent of Hispanics is unexpected. For cluster 4 census tracts, no partial correlation was performed because there were no multiple variables were statistically significant.

In short, longitudinal analyses controlling for socioeconomic characteristics in 1970 lead to several outcomes. First, regardless of socioeconomic status of neighborhoods, except for extremely impoverished neighborhoods (cluster 4) in 1970, brownfield neighborhoods encountered significant socioeconomic declines from 1970 to 1980. However, patterns of changes for subsequent decades were distinctly different across the four clusters, possibly reflecting different coping abilities based on the relative affluence and impoverishment of the neighborhoods represented by clusters in the initial time period. Furthermore, socioeconomic declines in brownfield neighborhoods were associated also with increases in percent of African Americans from 1970 to 2000. As a result, brownfield neighborhoods were transformed into impoverished neighborhoods with high African American percentages. In contrast, changes in percent of Hispanics were significantly and independently associated with the presence of brownfields, but in the opposite direction compared to changes in African Americans was found, indicating that areas where Hispanic population increased were not adjacent to brownfields. This finding indicates not all racial minorities necessarily share the same kind of environmental inequality and begs for further examinations of why Hispanics did not settle near brownfields. Finally, during the 1990s significant socioeconomic improvement for brownfield neighborhoods in clusters 2 and 3 census tracts became noticeable. This improvement might have resulted from the unusual economic prosperity of this decade, or it might have resulted from brownfield development policies initiated in the mid-1990s succeeding. In any case, brownfield development policies are relatively new and more time may need to pass before we can fully evaluate their impacts on the socioeconomic conditions of nearby neighborhoods. The next chapter will address the third and final research question, which is whether the socioeconomic conditions of neighborhoods adjacent to brownfields are associated with brownfield cleanup prioritizations.

Table 8-1 Socioeconomic characteristics of four clusters in 1970

	Cluster 1 (most affluent)		Cluster 2		Cluster 3		Cluster 4 (most impoverished)	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Socioeconomic Variables								
Female-head Families with Dependent Children	2.31%	1.31%	3.29%	1.50%	4.64%	2.26%	16.75%	5.87%
Unemployed Person	3.04%	0.92%	3.90%	1.54%	5.75%	2.24%	10.34%	2.96%
Households with Public Assistance	0.80%	0.69%	1.41%	0.98%	2.98%	1.87%	14.69%	5.27%
Persons below Poverty	2.64%	1.72%	3.47%	1.49%	6.18%	3.16%	22.94%	7.37%
Average Household Income	$23,482	7,502	$14,595	1,883	$11,612	1,386	$8,071	1,302
Average Owner-Occupied Housing Value	$42,755	6,284	$26,947	5,223	$19,735	4,339	$12,289	3,004
Less than High School Diploma	16.67%	5.25%	34.86%	6.45%	52.14%	9.16%	67.77%	8.14%
Bachelor's Degree or Higher	33.22%	7.08%	13.46%	5.21%	5.46%	2.86%	3.49%	2.97%
White Collar Occupations	51.32%	6.82%	30.11%	6.01%	16.70%	5.52%	9.84%	5.31%
Blue Collar Occupations	12.59%	4.68%	30.01%	6.78%	42.02%	6.36%	43.00%	6.80%
Housing Variables								
Vacant Housing Units	3.60%	4.17%	2.40%	2.37%	3.27%	3.49%	8.93%	4.76%
Owner-Occupied Housing Units	83.02%	19.37%	84.76%	11.13%	79.72%	12.19%	45.88%	16.63%
Racial Variables (not included in cluster analysis)								
Non-Hispanic Whites	98.97%	3.32%	97.63%	10.82%	93.40%	18.46%	30.83%	30.83%
African Americans	0.65%	3.22%	2.03%	10.72%	6.23%	18.42%	68.45%	31.24%
Hispanics	0.76%	0.77%	0.78%	0.95%	1.24%	1.77%	2.63%	5.49%
N		115		328		561		140

Table 8-2 Racial and socioeconomic changes of cluster 1 census tracts (N=31) within a 1.0 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	98.42%	4.28%	91.26%	16.68%	82.70%	27.78%	74.79%	31.07%
African Americans	1.28%	4.28%	7.21%	16.37%	14.39%	27.65%	19.51%	32.16%
Hispanics	0.78%	0.78%	0.83%	0.58%	0.95%	0.66%	1.38%	0.89%
Socioeconomic Variables								
Female-head Families with Dependent Children	2.76%	1.53%	4.85%	3.19%	4.74%	4.43%	7.16%	7.82%
Unemployed Person	3.07%	0.85%	4.28%	1.85%	3.68%	1.92%	3.32%	2.64%
Households with Public Assistance	0.77%	0.57%	1.97%	1.00%	2.85%	2.53%	4.05%	4.66%
Persons below Poverty	3.12%	1.61%	3.02%	2.03%	3.79%	2.84%	4.42%	4.41%
Average Household Income ($1000)[a]	$98.99	$21.35	$88.28	$24.69	$94.29	$34.03	$92.63	$29.91
Average Housing Value ($1000)[a]	$178.33	$33.45	$199.92	$54.56	$192.22	$68.10	$261.28	$90.95
Less than High School Diploma	18.21%	5.41%	11.51%	5.41%	8.24%	5.02%	7.02%	4.55%
Bachelor's Degree or Higher	32.94%	7.81%	39.63%	9.78%	47.29%	11.92%	53.08%	13.60%
White Collar Occupations	51.26%	6.72%	47.86%	7.84%	53.20%	7.25%	56.53%	9.62%
Blue Collar Occupations	12.23%	4.45%	11.05%	4.30%	9.15%	3.74%	8.57%	4.02%
Housing Variables								
Vacant Housing Units	2.31%	2.62%	3.53%	3.38%	4.41%	3.16%	3.89%	2.68%
Owner-Occupied Housing Units	80.65%	22.51%	73.30%	25.01%	73.93%	26.79%	74.85%	26.91%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Table 8-3 Racial and socioeconomic changes of cluster 1 census tracts (N=84) beyond a 1.0 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	99.18%	2.90%	94.32%	9.94%	88.68%	15.72%	81.05%	21.46%
African Americans	0.42%	2.72%	3.28%	9.93%	7.10%	16.06%	12.54%	22.09%
Hispanics	0.75%	0.77%	0.72%	0.58%	1.04%	1.10%	1.63%	1.19%
Socioeconomic Variables								
Female-head Families with Dependent Children	2.14%	1.18%	2.90%	1.75%	3.18%	2.16%	4.10%	4.07%
Unemployed Person	3.02%	0.95%	4.01%	1.45%	3.26%	1.51%	2.78%	2.06%
Households with Public Assistance	0.81%	0.73%	1.48%	1.15%	2.09%	1.65%	2.77%	2.06%
Persons below Poverty	2.47%	1.74%	2.95%	8.41%	2.32%	2.17%	3.05%	2.25%
Average Household Income ($1000)[a]	$109.42	$37.40	$109.12	$34.18	$120.31	$47.83	$121.54	$44.30
Average Housing Value ($1000)[a]	$199.93	$24.21	$257.58	$68.15	$255.65	$102.84	$327.71	$142.77
Less than High School Diploma	16.10%	5.10%	9.24%	4.92%	7.23%	4.04%	6.18%	3.77%
Bachelor's Degree or Higher	33.32%	6.84%	43.57%	9.70%	50.30%	10.58%	56.11%	12.43%
White Collar Occupations	51.34%	6.89%	51.09%	7.72%	54.82%	7.87%	58.69%	8.53%
Blue Collar Occupations	12.72%	4.78%	9.76%	4.27%	7.51%	3.76%	7.74%	4.53%
Housing Variables								
Vacant Housing Units	4.08%	4.53%	4.22%	3.08%	5.06%	4.20%	3.55%	3.08%
Owner-Occupied Housing Units	83.90%	18.14%	84.55%	23.56%	81.10%	24.05%	84.58%	22.26%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Table 8-4 Racial and socioeconomic changes of cluster 2 census tracts (N=131) within a 1.0 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	96.67%	12.23%	84.07%	28.77%	76.91%	34.33%	69.39%	36.48%
African Americans	2.91%	12.13%	14.55%	28.91%	21.08%	34.68%	26.90%	37.40%
Hispanics	0.87%	0.81%	1.06%	0.85%	1.21%	1.12%	1.48%	1.36%
Socioeconomic Variables								
Female-head Families with Dependent Children	3.27%	1.41%	7.38%	5.57%	8.85%	7.97%	10.25%	7.58%
Unemployed Person	3.74%	1.16%	8.63%	3.57%	6.57%	4.04%	4.65%	2.89%
Households with Public Assistance	1.26%	0.78%	4.94%	3.63%	5.75%	5.77%	6.49%	5.44%
Persons below Poverty	3.56%	1.38%	5.26%	3.82%	7.08%	7.29%	6.83%	5.23%
Average Household Income ($1000)[a]	$65.01	$8.07	$61.12	$9.67	$59.49	$12.53	$63.57	$15.78
Average Housing Value ($1000)[a]	$109.93	$21.69	$119.81	$38.81	$95.09	$41.16	$137.71	$60.91
Less than High School Diploma	34.59%	6.27%	24.47%	7.29%	19.13%	7.18%	14.50%	6.77%
Bachelor's Degree or Higher	14.20%	5.33%	18.42%	8.43%	22.16%	11.16%	26.77%	13.38%
White Collar Occupations	31.04%	6.03%	30.43%	8.31%	33.59%	9.33%	36.64%	11.08%
Blue Collar Occupations	28.25%	7.11%	23.81%	6.01%	20.26%	5.76%	19.70%	6.31%
Housing Variables								
Vacant Housing Units	2.44%	2.47%	2.79%	2.41%	3.72%	2.77%	3.33%	2.18%
Owner-Occupied Housing Units	82.57%	11.80%	77.87%	15.47%	74.59%	16.98%	75.39%	17.90%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Table 8-5 Racial and socioeconomic changes of cluster 2 census tracts (N=197) beyond a 1.0 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	98.26%	9.75%	95.07%	14.36%	91.93%	18.74%	86.02%	23.80%
African Americans	1.45%	9.65%	3.57%	14.28%	6.07%	18.72%	10.36%	24.04%
Hispanics	0.73%	1.03%	0.84%	0.80%	1.18%	1.01%	1.78%	1.38%
Socioeconomic Variables								
Female-head Families with Dependent Children	3.30%	1.57%	5.26%	3.61%	5.62%	5.25%	7.32%	6.69%
Unemployed Person	4.01%	1.74%	7.57%	2.68%	5.32%	2.77%	3.86%	2.70%
Households with Public Assistance	1.24%	0.92%	3.58%	2.29%	3.90%	3.46%	4.12%	3.78%
Persons below Poverty	3.41%	1.57%	3.42%	2.14%	4.33%	4.23%	5.11%	5.16%
Average Household Income ($1000)[a]	$67.10	$8.77	$68.20	$14.14	$68.92	$22.48	$73.79	$27.75
Average Housing Value ($1000)[a]	$115.77	$23.16	$146.94	$53.25	$121.03	$56.90	$169.22	$89.11
Less than High School Diploma	35.05%	6.58%	23.28%	7.33%	16.95%	6.46%	12.14%	5.65%
Bachelor's Degree or Higher	12.96%	5.07%	18.63%	8.96%	23.06%	11.41%	28.91%	14.38%
White Collar Occupations	29.49%	5.94%	30.93%	8.84%	35.35%	9.21%	39.22%	12.38%
Blue Collar Occupations	31.18%	6.31%	24.31%	6.48%	20.02%	5.74%	19.46%	9.15%
Housing Variables								
Vacant Housing Units	2.36%	2.31%	2.87%	2.90%	3.33%	2.79%	2.89%	2.02%
Owner-Occupied Housing Units	86.21%	10.45%	83.62%	14.69%	81.86%	15.86%	81.88%	17.30%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Table 8-6 Racial and socioeconomic changes of cluster 3 census tracts (N=280) within a 1.0 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	89.16%	23.50%	73.79%	33.99%	63.16%	39.79%	55.72%	41.06%
African Americans	10.42%	23.46%	24.50%	34.38%	34.24%	40.45%	40.22%	42.19%
Hispanics	1.41%	1.76%	2.04%	3.30%	2.45%	5.06%	4.08%	9.49%
Socioeconomic Variables								
Female-head Families with Dependent Children	5.28%	2.49%	13.64%	8.72%	19.86%	14.40%	19.64%	12.53%
Unemployed Person	5.70%	2.09%	14.92%	5.07%	13.77%	8.56%	9.83%	5.88%
Households with Public Assistance	3.39%	1.99%	12.07%	7.31%	16.68%	12.36%	15.01%	10.63%
Persons below Poverty	6.65%	3.15%	11.63%	7.96%	20.18%	15.12%	17.41%	12.01%
Average Household Income ($1000)[a]	$50.78	$6.23	$46.44	$8.99	$41.11	$10.66	$45.51	$10.59
Average Housing Value ($1000)[a]	$80.41	$16.40	$71.19	$30.21	$56.49	$30.47	$86.87	$39.78
Less than High School Diploma	54.36%	8.76%	41.76%	9.47%	33.70%	9.81%	27.01%	10.26%
Bachelor's Degree or Higher	5.05%	2.84%	6.71%	3.93%	7.87%	5.27%	10.08%	7.76%
White Collar Occupations	15.73%	5.08%	16.39%	5.45%	19.26%	6.25%	20.37%	8.21%
Blue Collar Occupations	41.41%	6.74%	35.15%	6.14%	29.94%	5.84%	28.80%	6.97%
Housing Variables								
Vacant Housing Units	2.50%	1.98%	4.22%	3.04%	5.12%	3.10%	6.55%	4.27%
Owner-Occupied Housing Units	77.97%	12.52%	72.39%	15.24%	65.19%	17.39%	66.25%	17.11%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Table 8-7 Racial and socioeconomic changes of cluster 3 census tracts (N=281) beyond a 1.0 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	97.62%	9.75%	94.88%	13.32%	93.14%	14.72%	88.26%	17.72%
African Americans	2.06%	9.74%	3.52%	13.23%	4.55%	14.63%	7.55%	17.36%
Hispanics	1.08%	1.77%	1.40%	1.79%	1.84%	2.58%	2.82%	4.91%
Socioeconomic Variables								
Female-head Families with Dependent Children	4.01%	1.80%	7.27%	5.28%	7.96%	6.44%	9.27%	9.15%
Unemployed Person	5.81%	2.39%	10.62%	3.64%	6.67%	3.46%	4.75%	2.91%
Households with Public Assistance	2.57%	1.64%	6.02%	4.40%	5.86%	5.35%	5.65%	4.98%
Persons below Poverty	5.71%	3.11%	5.94%	4.48%	7.13%	7.04%	7.26%	8.50%
Average Household Income ($1000)[a]	$54.66	$5.74	$57.91	$10.37	$58.49	$15.24	$65.15	$19.39
Average Housing Value ($1000)[a]	$98.76	$18.42	$124.89	$40.71	$110.90	$44.09	$161.94	$61.18
Less than High School Diploma	49.92%	9.03%	30.28%	10.72%	21.94%	8.99%	16.45%	9.67%
Bachelor's Degree or Higher	5.87%	2.82%	12.00%	6.81%	14.57%	8.43%	20.49%	11.62%
White Collar Occupations	17.66%	5.77%	22.53%	7.66%	26.66%	8.51%	31.12%	11.11%
Blue Collar Occupations	42.62%	5.90%	33.54%	6.63%	27.73%	6.56%	25.44%	7.46%
Housing Variables								
Vacant Housing Units	4.04%	4.40%	4.16%	3.01%	4.68%	3.81%	4.54%	3.34%
Owner-Occupied Housing Units	81.46%	11.61%	77.30%	17.35%	75.51%	18.98%	77.69%	19.63%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Table 8-8 Racial and socioeconomic changes of cluster 4 census tracts (N=98) within a 0.5 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	27.97%	28.26%	17.80%	21.92%	12.26%	17.35%	10.08%	15.43%
African Americans	71.19%	28.83%	79.11%	26.48%	84.55%	22.64%	86.18%	21.99%
Hispanics	2.51%	5.52%	2.84%	6.89%	2.79%	7.59%	4.56%	13.09%
Socioeconomic Variables								
Female-head Families with Dependent Children	16.80%	5.22%	29.49%	9.69%	31.60%	11.06%	30.11%	11.28%
Unemployed Person	10.11%	2.87%	24.92%	7.53%	28.59%	10.19%	18.60%	8.13%
Households with Public Assistance	14.71%	4.92%	30.94%	8.10%	33.93%	10.29%	28.29%	9.68%
Persons below Poverty	23.03%	7.14%	33.49%	8.90%	43.27%	11.04%	34.53%	10.28%
Average Household Income ($1000)[a]	$36.30	$5.87	$30.99	$8.39	$26.44	$10.23	$33.74	$10.35
Average Housing Value ($1000)[a]	$54.94	$13.53	$43.35	$23.17	$31.95	$17.24	$59.48	$43.68
Less than High School Diploma	67.88%	8.16%	54.84%	11.45%	46.21%	12.37%	36.59%	11.37%
Bachelor's Degree or Higher	3.58%	3.14%	6.50%	8.86%	8.80%	11.88%	9.32%	10.44%
White Collar Occupations	10.07%	5.56%	16.68%	9.48%	21.61%	14.86%	20.11%	11.85%
Blue Collar Occupations	42.86%	6.96%	31.43%	10.62%	23.50%	8.51%	23.53%	8.52%
Housing Variables								
Vacant Housing Units	9.46%	4.73%	12.03%	5.72%	11.60%	5.64%	15.90%	8.29%
Owner-Occupied Housing Units	45.86%	17.77%	39.57%	18.39%	39.02%	18.22%	40.41%	18.49%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Table 8-9 Racial and socioeconomic changes of cluster 4 census tracts (N=42) beyond a 0.5 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	37.48%	35.60%	30.41%	34.26%	26.08%	33.48%	20.28%	28.32%
African Americans	62.04%	35.82%	67.19%	36.66%	71.41%	36.08%	73.86%	34.67%
Hispanics	2.91%	5.47%	3.38%	6.66%	2.96%	8.57%	5.71%	14.21%
Socioeconomic Variables								
Female-head Families with Dependent Children	16.61%	7.23%	29.30%	12.45%	33.31%	11.31%	32.84%	15.80%
Unemployed Person	10.90%	3.13%	21.83%	7.32%	25.31%	9.95%	16.57%	8.06%
Households with Public Assistance	14.64%	6.06%	28.77%	9.88%	34.77%	10.69%	28.01%	9.53%
Persons below Poverty	22.71%	7.97%	30.24%	10.89%	41.82%	13.08%	34.43%	12.61%
Average Household Income ($1000)[a]	$37.44	$6.00	$32.72	$7.45	$25.55	$6.39	$34.52	$9.10
Average Housing Value ($1000)[a]	$57.78	$13.85	$50.30	$35.33	$36.41	$21.74	$71.41	$91.65
Less than High School Diploma	67.54%	8.20%	54.43%	10.27%	47.81%	9.79%	39.15%	11.47%
Bachelor's Degree or Higher	3.30%	2.55%	5.57%	6.17%	6.21%	6.56%	7.36%	5.85%
White Collar Occupations	9.30%	4.71%	15.04%	10.40%	16.82%	8.25%	17.81%	9.99%
Blue Collar Occupations	43.33%	6.49%	33.97%	9.43%	25.50%	10.15%	25.50%	10.75%
Housing Variables								
Vacant Housing Units	7.71%	4.66%	11.09%	6.39%	11.84%	9.05%	13.55%	6.79%
Owner-Occupied Housing Units	45.94%	13.80%	42.29%	15.67%	39.15%	13.79%	41.46%	13.55%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Table 8-10 Aggregated numbers of persons by race by cluster

Cluster 1 (a)	Non-brownfield (N=84)				Brownfield (N=31)			
	1970	1980	1990	2000	1970	1980	1990	2000
# Persons	220,253	244,216	274,214	283,885	107,531	106,801	103,881	104,061
# Whites	218,452	231,388	244,104	230,436	105,801	97,490	86,432	78,476
# African Americans	767	7,608	19,048	35,168	1,450	7,636	14,244	19,132

Cluster 2 (b)	Non-brownfield (N=197)				Brownfield (N=131)			
	1970	1980	1990	2000	1970	1980	1990	2000
# Persons	633,243	642,935	646,537	689,495	516,314	509,371	491,030	489,689
# Whites	618,760	608,420	590,384	589,921	494,964	418,204	369,240	336,247
# African Americans	12,641	25,959	43,183	72,437	19,102	84,081	112,139	134,769

Cluster 3 (c)	Non-brownfield (N=281)				Brownfield (N=280)			
	1970	1980	1990	2000	1970	1980	1990	2000
# Persons	697,745	881,075	944,881	1,104,562	1,175,539	1,098,149	1,034,093	1,004,393
# Whites	677,979	832,488	879,631	979,100	1,032,207	787,257	640,024	558,711
# African Americans	17,254	34,044	42,402	76,113	138,142	290,824	366,524	402,670

Cluster 4[a] (d)	Non-brownfield (N=42)				Brownfield (N=98)			
	1970	1980	1990	2000	1970	1980	1990	2000
# Persons	245,653	174,594	133,058	118,524	517,291	358,202	260,653	221,877
# Whites	92,111	49,160	35,243	30,033	129,673	51,635	24,643	18,713
# African Americans	152,180	121,867	94,230	80,572	383,708	298,083	228,860	195,081

[a] 0.5 radius from brownfields

Table 8-11 Correlation matrix[a] of racial and socioeconomic changes[b] between brownfield and non-brownfield neighborhoods from 1970 to 2000 (clusters 1 and 2 census tracts)

	Cluster 1 (N=114): most affluent						Cluster 2 (N=328): second most affluent					
	(a)		(b)		(c)		(d)		(e)		(f)	
	70-80		80-90		90-00		70-80		80-90		90-00	
Racial Variables												
%African Americans	0.1417		0.1347		-0.0169		0.2736	***	0.1910	***	0.0740	
%Hispanics	-0.1031		-0.1511		-0.1661		-0.0559		-0.2428	***	-0.2718	***
Socioeconomic Variables												
%Female-head Families with Dependent Children	0.2523	**	-0.0906		0.1735		0.2386	***	0.1271	***	-0.0357	
%Unemployed Person	0.0537		0.0391		0.0213		0.1840	**	0.0302		-0.0961	
%Households with Public Assistance	0.1738		0.0606		0.0924		0.2084	***	0.0835		0.0834	
%Persons below Poverty	-0.0345		0.0867		-0.0212		0.2725	***	0.1125	*	-0.1238	*
Average Household Income ($1000)[c]	-0.2658	**	-0.1255		0.1202		-0.2402	***	-0.1785	**	0.1124	*
Average Housing Value ($1000)[c]	0.2319	*	-0.0147		0.2319	*	-0.1823	**	-0.1774	**	0.1823	**
%Less than High School Diploma	0.0150		-0.1604		-0.0278		0.1259	*	0.1047		0.0235	
%Bachelor's Degree or Higher	-0.2548	*	0.0606		-0.0015		-0.1176	*	-0.0666		-0.0898	
%White Collar Occupations	-0.2201	*	0.1167		-0.0533		-0.1421	*	-0.1388	*	-0.0718	
%Blue Collar Occupations	0.2232	*	0.0511		-0.1242		0.1882	**	0.0981		0.0427	
Housing Variables												
%Vacant Housing Units	0.1239		0.0044		0.1607		-0.0246		0.0887		0.0160	
%Owner-Occupied Housing Units	-0.1839	*	0.1744		-0.1082		-0.0887		-0.0869		0.0273	

* p > 0.05 ** p > 0.01 *** p > 0.001

[a] The dependent variable is whether census tracts are located within or beyond a 1.0 mile radius from brownfields.

[b] Changes refer to percentage difference from two time periods (i.e., percentage difference of white between 1970 and 1980 = %white80 - %white70) except for average household income and average housing value. They are computed based on ratio difference between two periods (i.e., percentage difference of average household income between 1970 and 1980 =[income70 - income60]/income60).

[c] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Table 8-12 Correlation matrix[a] of racial and socioeconomic changes[b] between brownfield and non-brownfield neighborhoods from 1970 to 2000 (clusters 3 and 4 census tracts)

	Cluster 3 (N=561): second most impoverished						Cluster 4 (N=139)[c]: most impovrished					
	(a)		(b)		(c)		(d)		(e)		(f)	
	70-80		80-90		90-00		70-80		80-90		90-00	
Racial Variables												
%African Americans	0.3547	***	0.3475	***	0.1685	***	0.0621		0.0651		0.0643	
%Hispanics	-0.2052	***	-0.3528	***	-0.4000	***	-0.1284		-0.1567		-0.1543	
Socioeconomic Variables												
%Female-head Families with Dependent Children	0.3605	***	0.3524	***	-0.1045	*	-0.0003		-0.0773		-0.0336	
%Unemployed Person	0.4253	***	0.2880	***	-0.2337	***	0.2268	**	0.0094		-0.0211	
%Households with Public Assistance	0.4364	***	0.3653	***	-0.1486	***	0.1047		-0.1769	*	0.0766	
%Persons below Poverty	0.3937	***	0.4416	***	-0.2313	***	0.1410		-0.0880		-0.0154	
Average Household Income ($1000)[d]	-0.4623	***	0.0131		0.1126	**	-0.0342		-0.0148		0.1125	
Average Housing Value ($1000)[d]	-0.2300	***	-0.3730	***	0.2300	**	-0.0433		0.0330		-0.0433	
%Less than High School Diploma	0.4200	***	0.0258		-0.1092	*	0.0072		-0.1206		-0.0546	
%Bachelor's Degree or Higher	-0.4213	***	-0.1804	***	-0.3129	***	0.0427		0.1368		-0.1389	
%White Collar Occupations	-0.3312	***	-0.1200	*	-0.2505	***	0.0579		0.1219		-0.1081	
%Blue Collar Occupations	0.2230	***	0.0574		0.1012	*	-0.0958		0.0211		0.0220	
Housing Variables												
%Vacant Housing Units	0.1977	***	0.0578		0.2187	***	-0.0838		-0.0905		0.1351	
%Owner-Occupied Housing Units	-0.0584		-0.3028	***	-0.0736		-0.0762		0.1554		-0.0447	

* p > 0.05 ** p > 0.01 *** p > 0.001

[a] The dependent variable is whether census tracts are located within or beyond a 1.0 mile radius from brownfields.

[b] Changes refer to percentage difference from two time periods (i.e., percentage difference of white between 1970 and 1980 = %white80 - %white70) except for average household income and average housing value. They are computed based on ratio difference between two periods (i.e., percentage difference of average household income between 1970 and 1980 =[income70 - income60]/income60).

[c] Census Tracts within a 0.5 mile radius from brownfields rather than 1.0 mile

[d] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Table 8-13 Partial correlation – matrix between racial and socioeconomic changes[a] the presence of brownfields from 1970 to 2000 (1.0 mile radius from brownfields)

	Cluster 1	Cluster 2			Cluster 3			Cluster 4
	(a)	(b)	(d)		(e)	(f)	(g)	(h)
	70-80	70-80	80-90	90-00	70-80	80-90	90-00	70-80
Racial Variables								
%African Americans	–	0.1328 *	0.1085 *	–	0.0997 *	0.0213	0.0917 *	–
%Hispanics	–	–	-0.1893 **	-0.2151 ***	-0.0887 *	-0.1922 ***	-0.2038 ***	–
Socioeconomic Variables								
%Female-head Families with Dependent Children	0.1380	0.0037	0.0402	–	-0.0057	-0.0078	-0.0668	–
%Unemployed Person	–	0.0124	–	–	0.0712	-0.0032	-0.0430	–
%Households with Public Assistance	–	-0.0475	–	–	0.0265	0.0181	-0.0228	–
%Persons below Poverty	-	0.0276	-0.0510	-0.0074	-0.0119	0.1183 **	-0.0242	–
Average Household Income	-0.0520	-0.1398 *	-0.1248 *	0.0828	0.1162 **	–	0.0041	–
Average Owner-Occupied Housing Value	0.0662	0.0606	0.0044	0.0015	0.0398	-0.1529 ***	0.1248 **	–
%Less than High School Diploma	–	0.0635	–	–	0.1217 **	–	-0.1080 *	–
%Bachelor's Degree or Higher	-0.0421	0.0616	–	–	-0.0897	-0.0121	-0.1641 ***	–
%White Collar Occupations	-0.1162	-0.0364	0.0424	–	-0.0277	0.0288	-0.0339	–
%Blue Collar Occupations	0.1145	-0.0116	–	–	-0.1010 *	–	0.0158	–
Housing Variables								
%Vacant Housing Units	–	–	–	–	0.0600	–	0.0427	–
%Owner-Occupied Housing Units	-0.1572	–	–	–	–	-0.0514	–	–
Number of census tracts	114	328	328	328	561	561	561	139

* p > 0.05 ** p > 0.01 *** p > 0.001

[a] Changes refer to percentage difference from two time periods (i.e., percentage difference of white between 1970 and 1980 = %white80 - %white70) except for average household income and average housing value. They are computed based on ratio difference between two periods (i.e., percentage difference of average household income between 1970 and 1980 =[income70 - income60]/income60).

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Table 8-14 Summary of findings with respect to socioeconomic changes between brownfield and non-brownfield neighborhoods by cluster by decade

	1970-1980	1980-1990	1990-2000
Cluster 1	Brownfield neighborhoods experienced greater socioeconomic declines than did non-brownfield neighborhoods	No significant socioeconomic decline between brownfield and non-brownfield neighborhoods was found	No significant socioeconomic decline between brownfield and non-brownfield neighborhoods was found
Cluster 2	Brownfield neighborhoods experienced greater socioeconomic declines than did non-brownfield neighborhoods	Brownfield neighborhoods continued to experience greater socioeconomic declines than non-brownfield neighborhoods. However, the magnitude of decline decreased compared to the one in the previous decade.	Brownfield neighborhoods experienced a greater socioeconomic improvement than did non-brownfield neighborhoods
Cluster 3	Brownfield neighborhoods experienced greater socioeconomic declines than did non-brownfield neighborhoods	Brownfield neighborhoods continued to experience greater socioeconomic declines than non-brownfield neighborhoods. The magnitude of decline was similar to the one in the previous decade.	Brownfield neighborhoods experienced a greater socioeconomic improvement than did non-brownfield neighborhoods
Cluster 4	No significant socioeconomic decline between brownfield and non-brownfield neighborhoods was found	No significant socioeconomic decline between brownfield and non-brownfield neighborhoods was found	No significant socioeconomic decline between brownfield and non-brownfield neighborhoods was found

Figure 8-1 Geographical locations of clusters 1-4 census tracts in the tri-county area

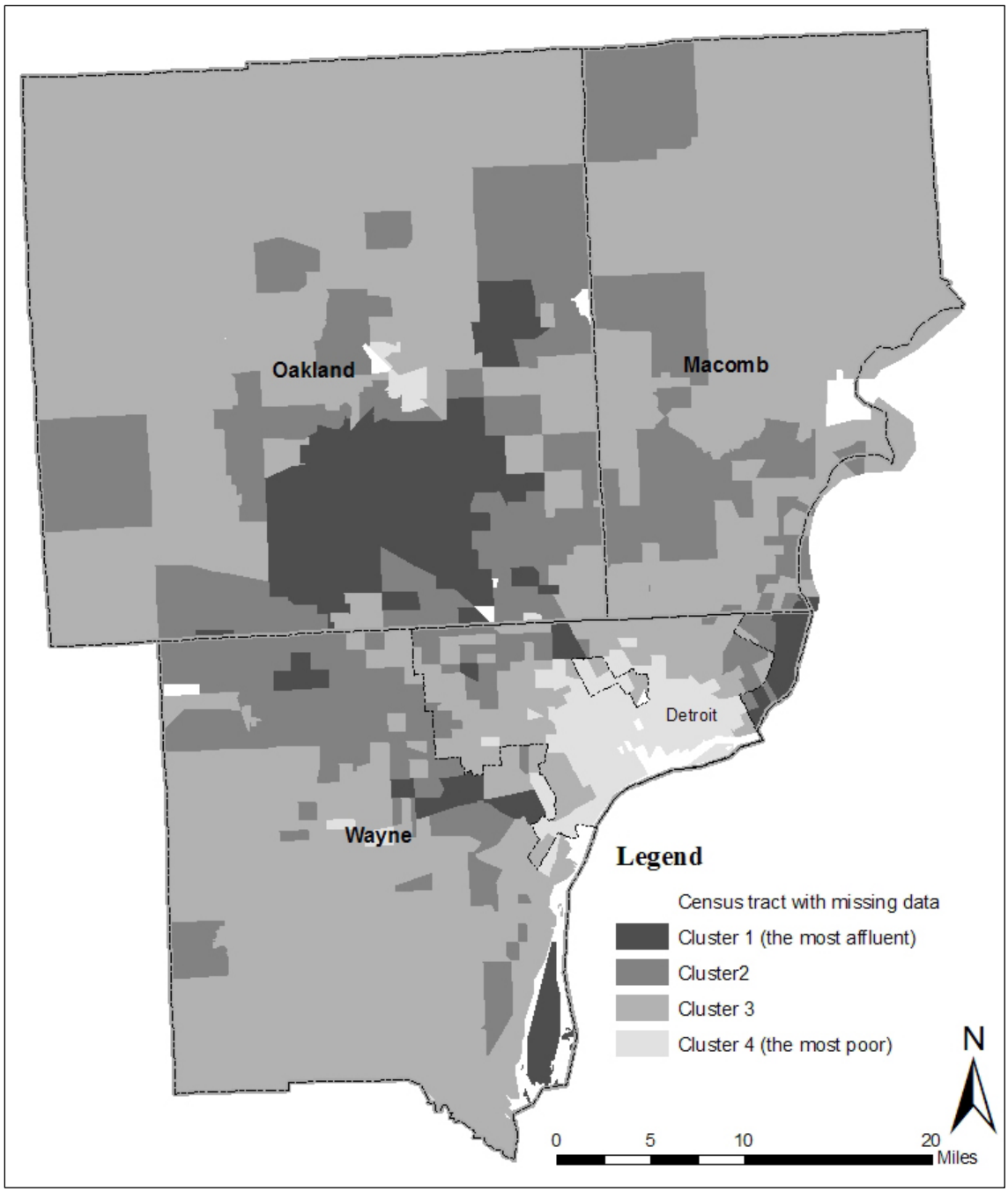


Figure 8-2 Percent of African Americans 1970-2000 between brownfield and non-brownfield neighborhoods in 1.0 mile radius with the 50% areal containment method (cluster 1 in 1970)

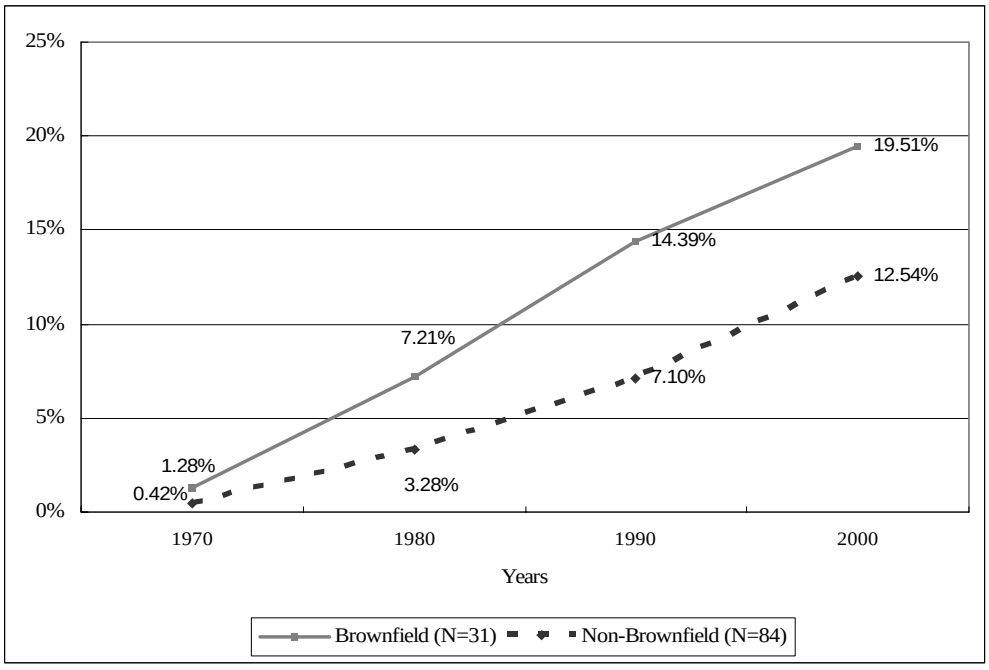


Figure 8-3 Average household income 1970-2000 (in constant 1999 dollars) between brownfield and non-brownfield neighborhoods in 1.0 mile radius with the 50% areal containment method (cluster 1 in 1970)

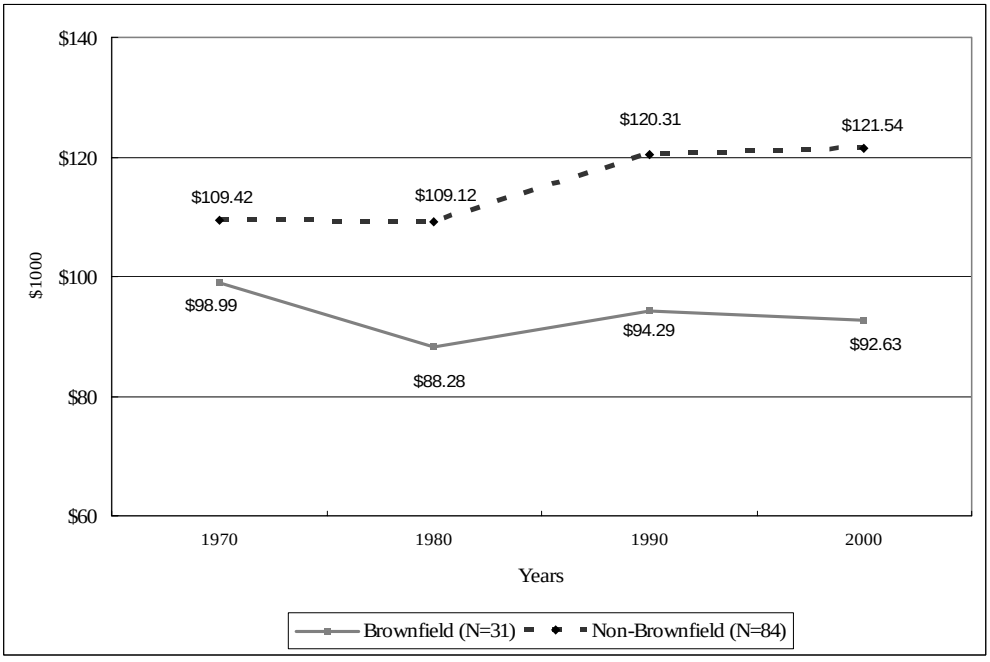


Figure 8-4 Average housing values 1970-2000 (in constant 1999 dollars) between brownfield and non-brownfield neighborhoods in 1.0 mile radius with the 50% areal containment method (cluster 1 in 1970)

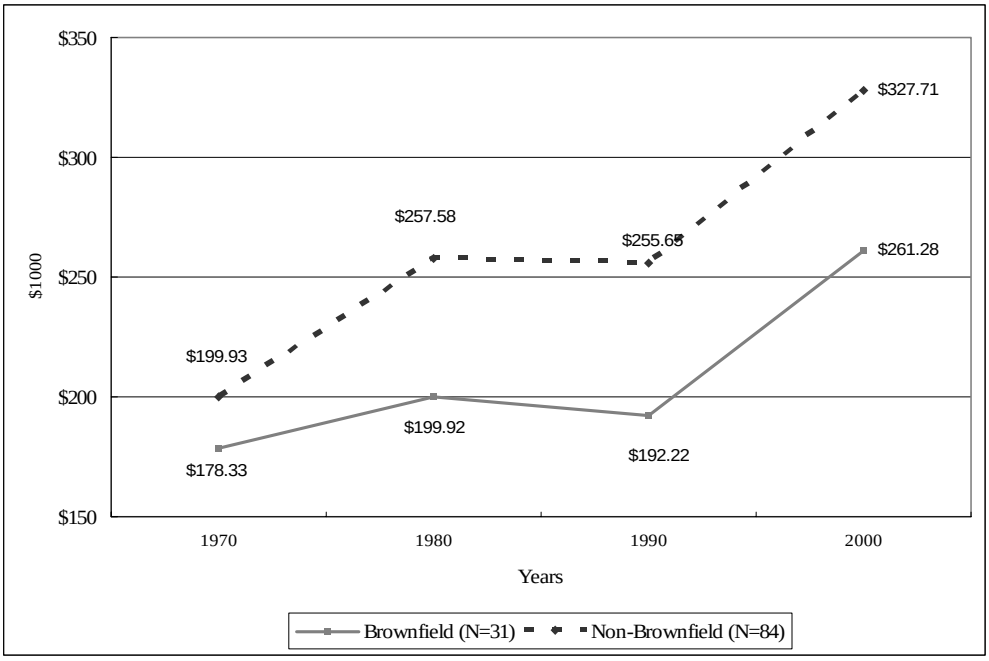


Figure 8-5 Percent of African Americans 1970-2000 between brownfield and non-brownfield neighborhoods in 1.0 mile radius with the 50% areal containment method (cluster 2 in 1970)

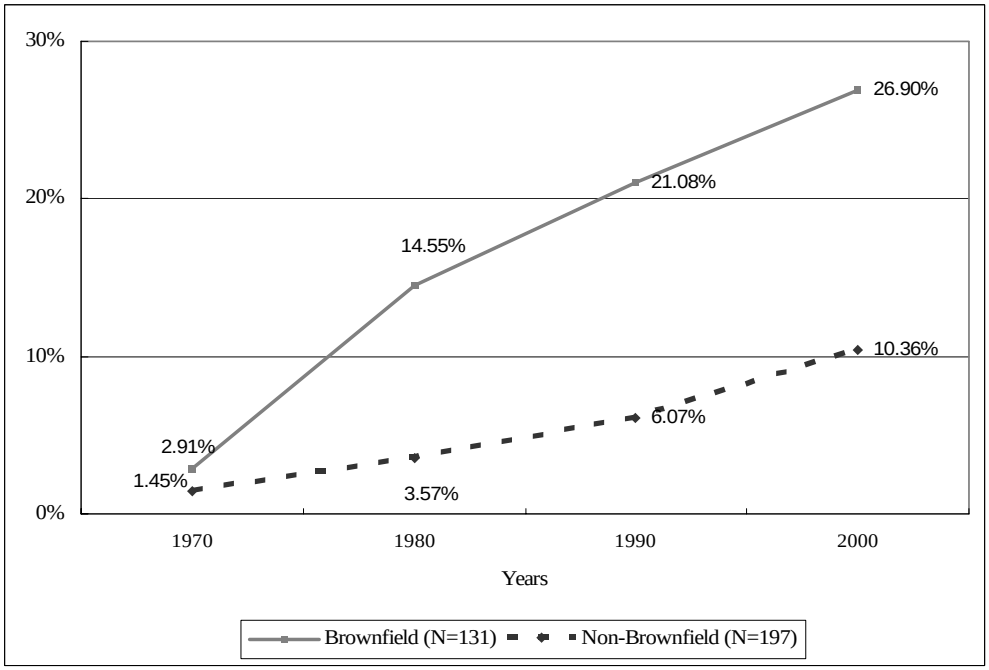


Figure 8-6 Average household income 1970-2000 (in constant 1999 dollars) between brownfield and non-brownfield neighborhoods in 1.0 mile radius with the 50% areal containment method (cluster 2 in 1970)

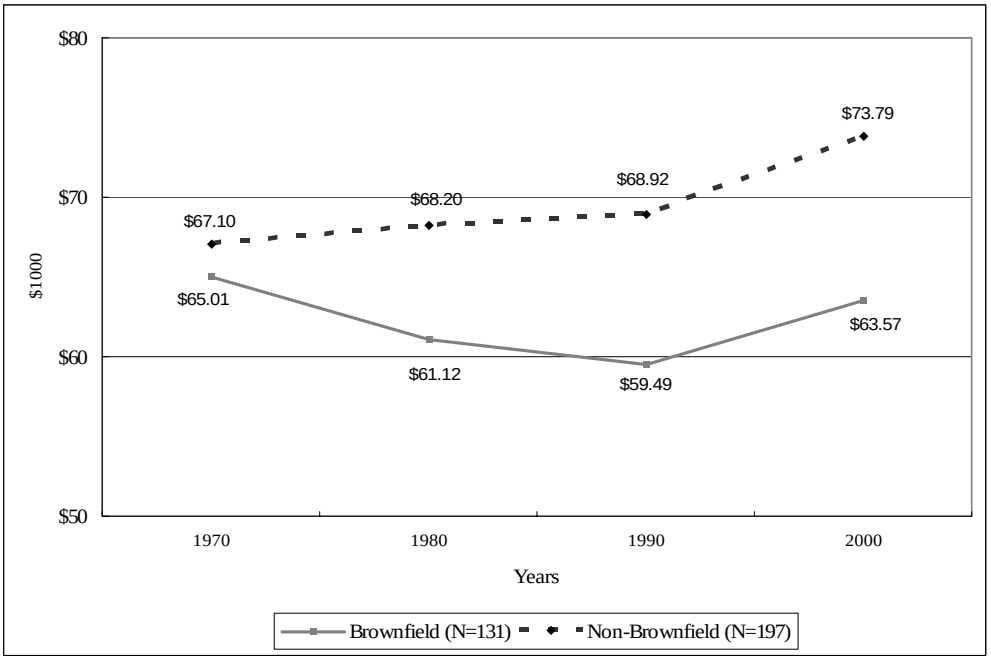


Figure 8-7 Average housing value 1970-2000 (in constant 1999 dollars) between brownfield and non-brownfield neighborhoods in 1.0 mile radius with the 50% areal containment method (cluster 2 in 1970)

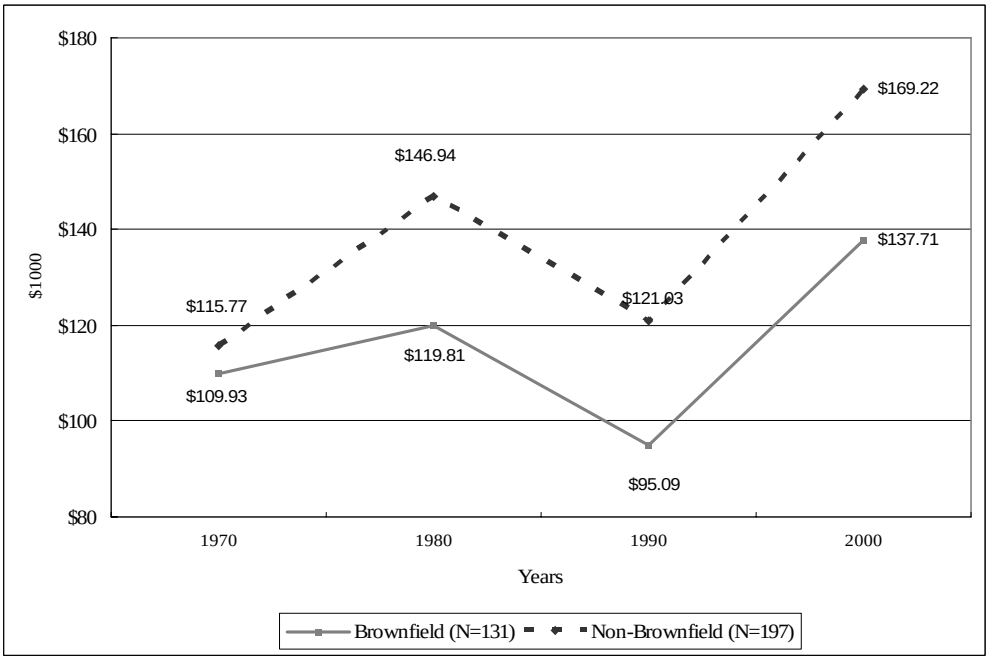


Figure 8-8 Percent of African Americans 1970-2000 between brownfield and non-brownfield neighborhoods in 1.0 mile radius with the 50% areal containment method (cluster 3 in 1970)

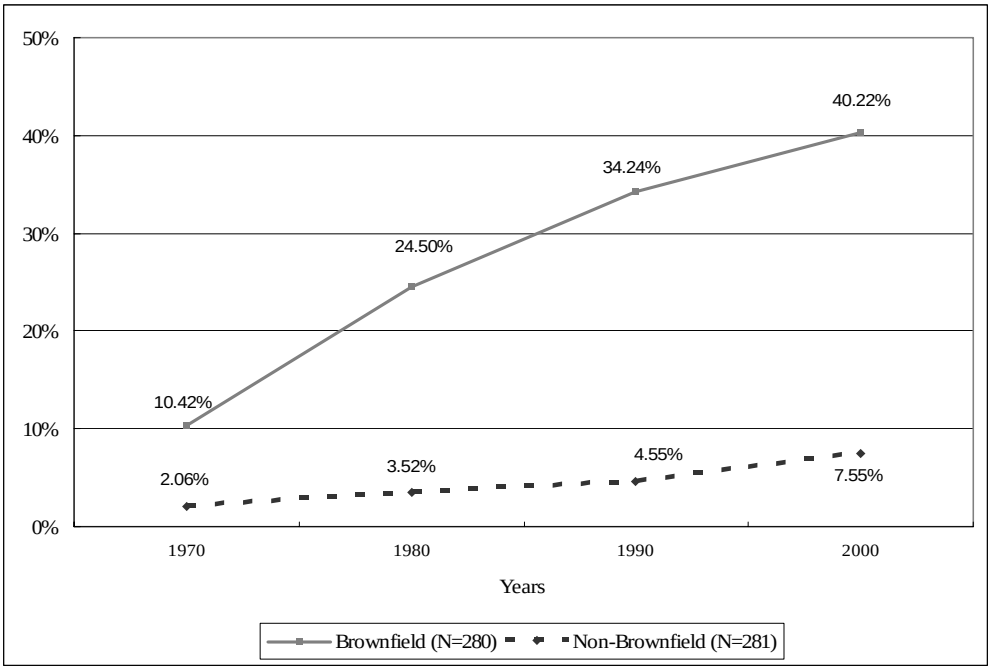


Figure 8-9 Average household income 1970-2000 (in constant 1999 dollars) between brownfield and non-brownfield neighborhoods in 1.0 mile radius with the 50% areal containment method (cluster 3 in 1970)

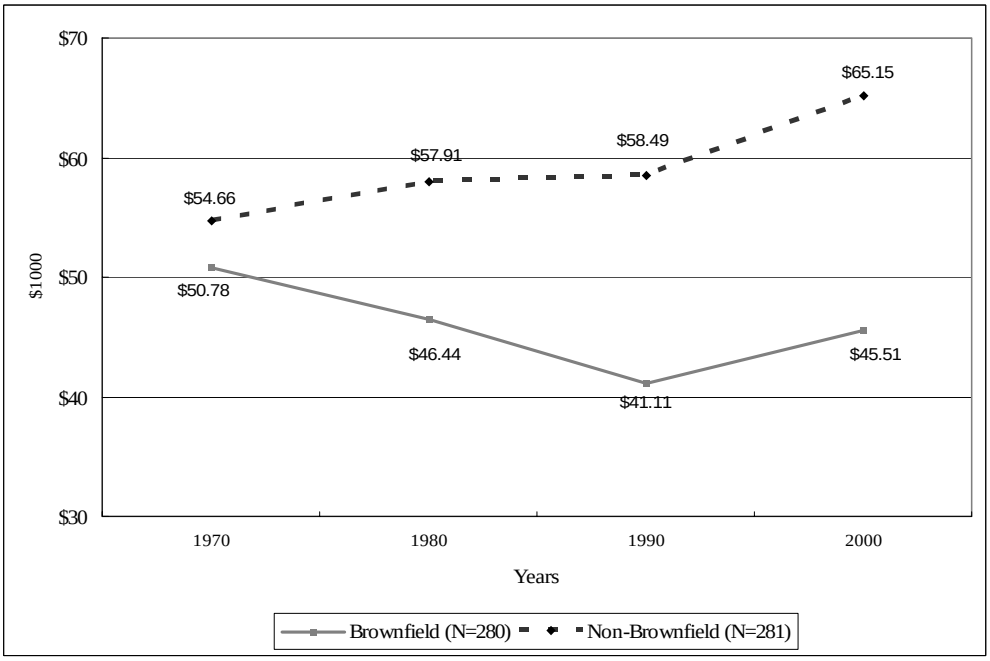


Figure 8-10 Average housing values 1970-2000 (in constant 1999 dollars) between brownfield and non-brownfield neighborhoods in 1.0 mile radius with the 50% areal containment method (cluster 3 in 1970)

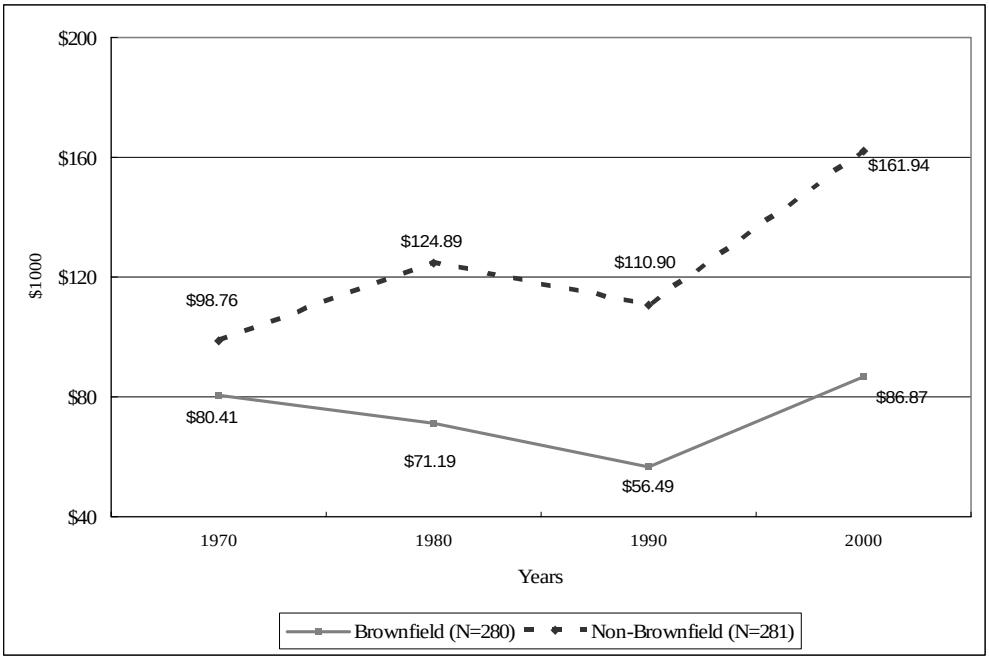


Figure 8-11 Percent of African Americans 1970-2000 between brownfield and non-brownfield neighborhoods in 1.0 mile radius with the 50% areal containment method (cluster 4 in 1970)

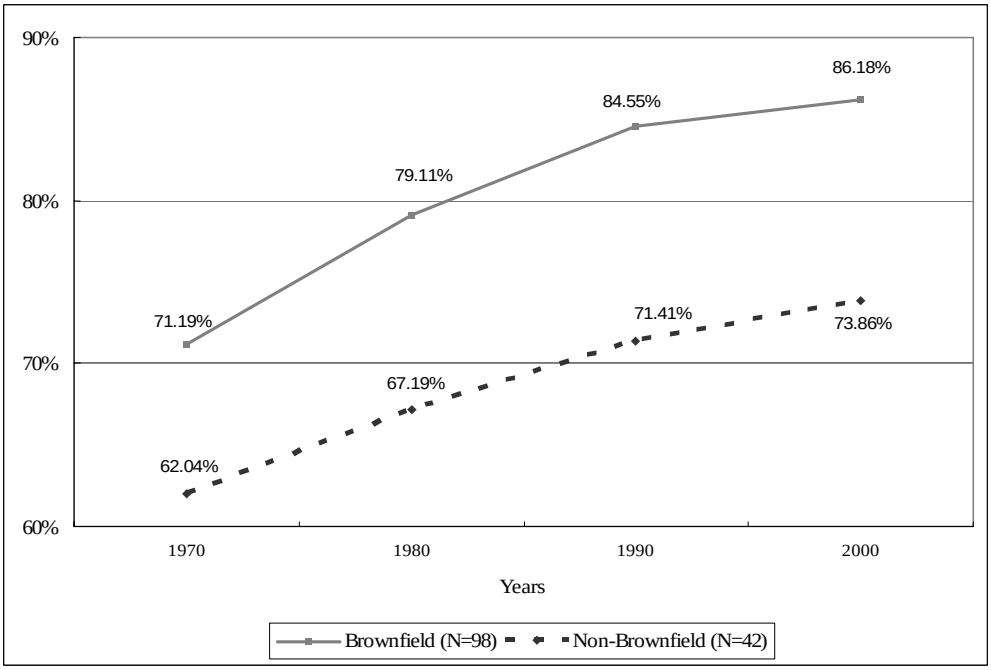


Figure 8-12 Average household income 1970-2000 (in constant 1999 dollars) between brownfield and non-brownfield neighborhoods in 1.0 mile radius with the 50% areal containment method (cluster 4 in 1970)

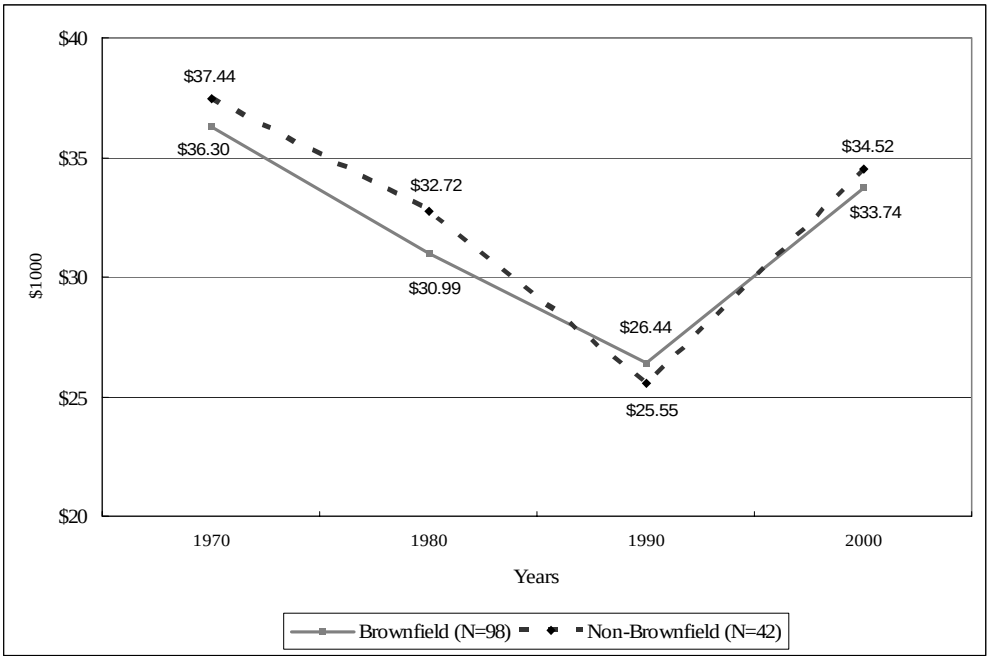
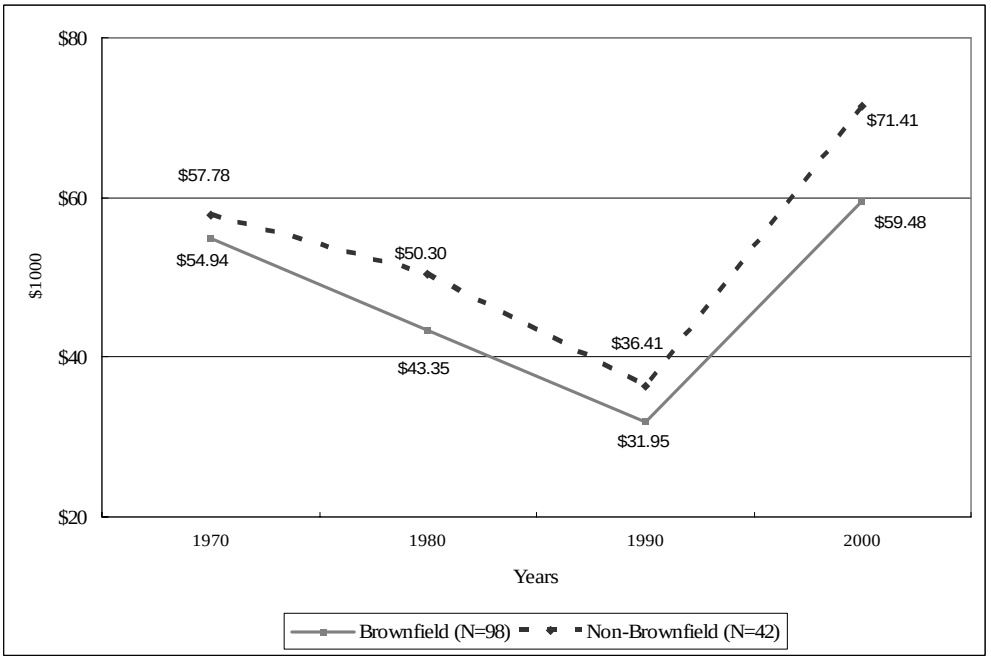


Figure 8-13 Average housing values 1970-2000 (in constant 1999 dollars) between brownfield and non-brownfield neighborhoods in 1.0 mile radius with the 50% areal containment method (cluster 4 in 1970)



CHAPTER 9 PRIORITIZATION OF BROWNFIELD CLEANUP

The previous two chapters examined how racial and socioeconomic characteristics of neighborhoods within and beyond a 1.0 mile radius from brownfields have experienced change from 1960 to 2000. Brownfield neighborhoods experienced greater socioeconomic decline than did non-brownfield neighborhoods from 1970 onward. Even when neighborhoods shared similar socioeconomic characteristics in 1970, brownfield neighborhoods for three most affluent census tracts (clusters 1, 2, and 3) experienced a greater decline in socioeconomic characteristics between 1970 and 1980, but patterns differ by cluster in subsequent decades. For the most affluent neighborhoods (cluster 1), no significant socioeconomic difference between brownfield and non-brownfield neighborhoods was found between 1980 and 2000. For less affluent neighborhoods (clusters 2 and 3), socioeconomic conditions of brownfield neighborhoods relative to non-brownfield neighborhoods continued to decline between 1980 and 1990. Between 1990 and 2000, brownfield neighborhoods experienced a greater socioeconomic improvement than did non-brownfield neighborhoods. For the most impoverished neighborhoods (cluster 4), there was no significant socioeconomic difference between brownfield and non-brownfield neighborhoods from 1970 to 2000.

This chapter examines whether the socioeconomic characteristics of neighborhoods within a 0.5 or 1.0 mile radius from brownfields are associated with brownfield cleanup prioritization. Environmental justice studies finds that cleaning up prioritization of contaminated sites such as Superfund National Priority List sites tend to give to wealthier and whiter neighborhoods (Anderton et al. 1997; Hamilton 1995; Zimmerman 1993) (see Chapter 4 for detailed reviews of those studies). Socioeconomic conditions of neighborhoods are a key to explain disparity of cleanup prioritization. That is, higher socioeconomic wealthy individuals tend to create social networks (or social cliques) to help each other. Through established social networks, they mutually support each other (Mill 1994). In addition, resource mobilization theory predicts that socioeconomically disadvantaged neighborhoods are unlikely to enjoy prompt brownfield cleanups because

socioeconomic status is important because those who have financial, informational, and other resources are more likely to mobilize and have influence. Finally, indirect institutionalized discrimination (Feagin and Feagin 1987) leads to predicting that neighborhoods with high minority concentrations are unlikely to enjoy cleanup prioritization of their brownfields even when controlling for socioeconomic characteristics (see chapter 4 for detailed discussion about the above explanations). This chapter thus examines whether racial and socioeconomic disparities exist in brownfield cleanup prioritization.

9-1 Data and Method

The unit of analysis in this chapter is the census block group within a 0.5 or 1.0 mile radius from brownfields in the study area. Furthermore, because the unit of analysis is the census block group, the centroid containment method (see chapter 5) is used to calculate the number of brownfields located within a 0.5 or 1.0 mile radius from block group centroids by cleanup status. Because the research question posed in this chapter asks whether the socioeconomic characteristics of neighborhoods near brownfields are associated with brownfield cleanup prioritization, census block groups beyond a 0.5 or 1.0 mile radius from brownfields are excluded from analyses. Because brownfield development in the state of Michigan started in the mid-1990s, data from the 1990 Census of Housing and Population are used rather than the 2000 Census of Housing and Population. A digitized map of census block groups in the study area also came from Geolytics.

Recalling from chapter 5, locations of brownfields are so concentrated that some census block groups have multiple brownfields whose cleanup statuses are different. In order to overcome this problem, brownfield cleanup statuses were grouped. For descriptive statistics, cleanup statuses are categorized into three groups on the basis of their similarities. The group combined cleanup statuses of ‘completed’ and ‘in progress,’ representing that cleanup actions have been carried out without any interruption. The second combined cleanup statuses of ‘not cleaned up’ and ‘time to be assigned,’ representing that cleanup actions have not been initiated. The third group combined cleanup statuses of ‘closed,’ ‘cancelled,’ and ‘pending,’ representing that cleanup actions have been initiated but these actions have been stopped (see Table 5-1 for

detailed information on those statuses). The purpose of this categorization is to examine racial and socioeconomic characteristics of census block groups adjacent to brownfields by category.

For statistical analyses, brownfield cleanup statuses were dichotomized – brownfields that cleanup actions have been initiated and brownfields that cleanup actions have not been initiated[1]. The logic of the above dichotomization is that five cleanup statuses of 'completed,' 'in progress,' 'closed,' 'cancelled,' and 'pending' share a common thread – cleanup actions have been initiated. Then, the percent of brownfields whose cleanup actions have been initiated as the dependent variable are computed by the number of brownfields of the above five cleanup statuses divided by a number of all the brownfields. It would be ideal if a consistent grouping strategy could be employed to avoid confusion. However, many census block groups were located adjacent to brownfields whose cleanup statuses differ, thus different categorization schemes were employed for descriptive statistics and statistical analyses. There are three sets of independent variables: racial, socioeconomic, and housing (see Appendix D for detailed information on the construction of these variables).

For statistical analyses, correlation is performed for bi-variate analyses while ordinary least squares regression is performed for multivariate analyses. The purpose of conducting multivariate regression analyses is to see whether racial variables maintain their explanatory power in predicting cleanup prioritization even when controlling for socioeconomic characteristics, which is the key to identify whether indirect institutionalized discrimination is supported as a reason for the disparity of brownfield cleanup prioritization.

9-2 Results

For descriptive statistics, the socioeconomic characteristics of census block groups within a 0.5 or 1.0 mile radius from brownfields with different cleanup statuses are presented, followed by the results of bi-variate and multivariate analyses. Before presenting results, it is critical to note that the word 'prioritization' in this chapter does not mean that policy makers consciously give cleanup priority to one brownfield over

[1] Cleanup statuses of 'completed,' 'in progress,' 'cancelled,' 'closed,' and 'pending' were combined for brownfields whose cleanup actions have been initiated while cleanup statuses of 'not cleaned up' and 'time to be assigned' were combined for brownfields whose cleanup actions have not been initiated.

others because it is unclear whether it is the case. Thus, 'prioritization' in this chapter rather refers to cleanup actions implicated through results.

9-2-1 Descriptive Statistics

Tables 9-1 and 9-2 show the racial and socioeconomic characteristics of census block groups within a 0.5 or 1.0 mile radius from brownfields by cleanup status group. Racial and socioeconomic characteristics of census block groups by cleanup category will be compared to racial and socioeconomic characteristics of census block groups within a 0.5 or 1.0 mile radius from all the brownfields because some census block groups are within a 0.5 or 1.0 mile radius from several brownfields whose cleanup statuses are different.

In general, racial and socioeconomic disparity was found in terms of brownfield cleanup prioritization but in the unexpected direction. When racial and socioeconomic characteristics of census block groups located within a 0.5 mile radius from brownfields whose cleanup actions are completed or in progress are compared to the characteristics of census block groups within a 0.5 mile radius from all the brownfields, the former census block groups show a higher percent of minority populations and lower socioeconomic characteristics than do the latter census block groups. For example, the percent of African Americans in census block groups within a 0.5 mile radius from brownfields whose cleanup actions have been competed or in progress in 1990 was 66% (see Table 9-1 (b)) while the percent in census block groups within a 0.5 mile radius from all the brownfields in 1990 was 55% (see Table 9-1 (a)). The average household income in census block groups within a 0.5 mile radius from brownfields whose cleanup actions have been competed or in progress in 1989 was $24,000 (see Table 9-1 (b)) while the average in census block groups within a 0.5 mile radius from all the brownfields in 1989 was $28,000 (see Table 9-1 (a)). Other socioeconomic variables show similar patterns.

When the racial and socioeconomic characteristics of census block groups located within a 0.5 mile radius from brownfields whose cleanup actions have not been initiated are compared to the characteristics of census block groups within a 0.5 mile radius from all the brownfields, the former census block groups show a lower percent of minority populations and higher socioeconomic characteristics than the latter census block groups. For instance, the percent of African Americans in census block groups within a 0.5 mile

radius from brownfields whose cleanup actions have not been initiated in 1990 was 45% (see Table 9-1 (c)) while the percent in census block groups within a 0.5 mile radius from all the brownfields in 1990 was 55% (see Table 9-1 (a)). The average household income in census block groups within a 0.5 mile radius from brownfields whose cleanup actions have not been initiated in 1989 was $31,000 while the average in census block groups within a 0.5 mile radius from all the brownfields in 1989 was $28,000 (see Table 9-2). Other socioeconomic variables show similar patterns.

Finally, when racial and socioeconomic characteristics of census block groups located within a 0.5 mile radius from brownfields whose cleanup actions have been stopped[2] are compared to the characteristics of census block groups within a 0.5 mile radius from all the brownfields, the former census block groups show a higher percent of minority populations and lower socioeconomic characteristics than the latter census block groups. For example, the percent of African Americans in census block groups within a 0.5 mile radius from brownfields whose cleanup actions have not been initiated in 1990 was 66% (Table 9-1 (d)) while the percent in census block groups within a 0.5 mile radius from all the brownfields in 1990 was 55% (see Table 9-1 (a)). The average household income in census block groups within a 0.5 mile radius from brownfields whose cleanup actions have been stopped in 1989 was $31,000 (see Table 9-1 (d)) while the average in census block groups within a 0.5 mile radius from all the brownfields in 1989 was $26,000 (see Table 9-2 (a)). Other socioeconomic variables show similar patterns.

In terms of other socioeconomic variables, brownfield cleanup prioritization tends to be given to census block groups with lower percents of persons who are not US citizens, of persons over 25 having bachelor's degree or higher, and of persons over 16 employing in white collar occupations. For example, 8.4% of persons over 25 in census block groups located within a 0.5 mile radius from brownfields whose cleanup actions are completed or in progress were were holding bachelor's degree or higher (see Table 9-1 (b)) while 10.1% of persons over 25 in census block groups located within a 0.5 mile radius from all the brownfields were holding bachelor's degree or higher (see Table 9-1 (a)). Twelve point two of persons over 25 in census block groups located within a 0.5

[2] Cleanup statuses of 'cancelled,' 'closed,' and 'pending' are combined.

mile radius from brownfields whose cleanup actions have not been initiated were holding bachelor's degree or higher (see Table 9-1 (c)) while 10.1% of persons over 25 in census block groups located within a 0.5 mile radius from all the brownfields were holding bachelor's degree or higher (see Table 9-1 (a)). Finally, 8.1% of persons over 25 in census block groups located within a 0.5 mile radius from brownfields whose cleanup actions have been stopped were holding bachelor's degree or higher (see Table 9-1 (d)) while 10.1% of persons over 25 in census block groups located within a 0.5 mile radius from all the brownfields were holding bachelor's degree or higher (see Table 9-1 (a)). Although census block groups that enjoy prompt brownfield cleanup have lower percent of persons who were not US citizens in 1990, differences were not noticeably different (1.7% for cleanup actions have been completed or in progress and 1.9% for all the brownfields).

In terms of housing variables, census block groups that received prompt cleanup actions appear to be unstable census block groups in 1990. For example, 52% of occupied housing units in census block groups located within a 0.5 mile radius from brownfields whose cleanup actions are 'completed' or 'in progress' were owner-occupied in 1990 (see Table 9-1 (b)), while 57% of occupied housing units in census block groups located within a 0.5 mile radius from all the brownfields were owner-occupied in 1990 (see Table 9-1 (a)). In addition, while 60% of occupied housing units in census block groups located within a 0.5 mile radius from brownfields whose cleanup actions have not been initiated were owner-occupied in 1990 (see Table 9-1 (c)), 57% of occupied housing units in census block groups located within a 0.5 mile radius from all the brownfields were owner-occupied in 1990 (see Table 9-1 (a)). Finally, while 54% of occupied housing units in census block groups located within a 0.5 mile radius from brownfields whose cleanup actions have been stopped were owner-occupied in 1990 (see Table 9-1 (d)), 57% of occupied housing units in census block groups located within a 0.5 mile radius from all brownfields were owner-occupied in 1990 (see Table 9-1 (a)).

When radius expands from 0.5 to 1.0 mile from brownfields, the same patterns are found. Census block groups near brownfields whose cleanup actions are completed or in progress show a higher percent of minorities and lower levels of socioeconomic characteristics than do census block groups near all the brownfields. Census block

groups near brownfields whose cleanup actions have not been initiated show a lower percent of minorities and higher levels of socioeconomic characteristics than do census block groups near all the brownfields. Finally, census block groups near brownfields whose cleanup actions have been stopped show a higher percent of minorities and lower levels of socioeconomic characteristics than do census block groups near all the brownfields (see Table 9-2).

A close examination of racial and socioeconomic conditions among the three different cleanup status categories yields an interesting pattern. Racial and socioeconomic conditions of census block groups located within a 0.5 or 1.0 mile radius from brownfields whose cleanup actions are 'completed' or 'in progress' are similar to the conditions of census block groups located within a 0.5 or 1.0 mile radius from brownfields whose cleanup actions are 'closed,' 'cancelled,' or 'pending.' This finding is not surprising given these two status group share the common thread, meaning that cleanup actions of brownfields with the above cleanup statuses have been initiated. In order for brownfields to be 'closed,' 'cancelled,' or 'pending' statuses, cleanup actions have had to be initiated. Therefore, the above finding confirms that impoverished and minority census block groups tend to enjoy a prompt initiation of brownfield cleanup actions.

In short, there is apparent racial and socioeconomic disparity in brownfield cleanup prioritization but in an unexpected direction. That is, nearby census block groups experiencing cleanup prioritization of brownfields show both higher levels of minority presence and lower levels of socioeconomic characteristics than do nearby census block groups not experiencing such prioritization. The next section conducts statistical tests to confirm that such findings are statistically significant.

9-2-2 Bi-variate Analysis

As noted, conducting statistical tests for brownfield cleanup prioritization on the basis of distinctive cleanup statuses proves to be difficult because brownfields of a variety of statuses are spatially concentrated. Therefore, the dependent variable for statistical tests is the percent of brownfields whose cleanup actions have been initiated[3]

[3] Cleanup statuses of 'completed,' 'in progress,' 'cancelled,' 'closed,' and 'pending' were combined for brownfields whose cleanup actions have been initiated while cleanup statuses of 'not cleaned up' and 'time

within a 0.5 or 1.0 mile radius from block group centroids over the number of all the brownfields within a 0.5 or 1.0 mile radius from block group centroids. A positive sign thus means that as the demographic value of a variable in census block groups increases, the percent of brownfields whose cleanup actions have been initiated within a 0.5 or 1.0 mile radius from block group centroids also increases.

When correlation analysis is performed, the racial and socioeconomic conditions of census block groups are found to be statistically significantly associated with the percent of brownfields whose cleanup actions have been initiated within a 0.5 or 1.0 mile radius from block group centroids. For example, a positive sign of the percent of African Americans (Table 9-3) indicates that census block groups with a higher proportion of African Americans indeed enjoy cleanup prioritization of their brownfields. When the radius expands from 0.5 to 1.0 mile, the same pattern is observed although the strength of correlation increases. For instance, the Pearson correlation coefficient between the percent of African Americans in census block groups and the percent of brownfields whose cleanup actions have been initiated within a 0.5 mile from block group centroid is 0.310. The correlation coefficient of the percent of African Americans increases to 0.419 when the radius expands to 1.0 mile (see Table 9-3).

In terms of socioeconomic characteristics, census block groups with lower levels of socioeconomic characteristics are more likely to be near brownfields that are prioritized for cleanup. For instance, the Pearson correlation coefficient between the percent of brownfields whose cleanup actions have been initiated within a 0.5 mile radius from block group centroids and the median household income is -0.302. This means that as the median income in census block groups decreases, the percent of brownfields whose cleanup actions have been initiated within a 0.5 mile radius from block group centroids also increases. Similarly with racial variables, when the radius expands from a 0.5 to 1.0 mile, the same pattern is observed although the strength of correlation coefficients increases. For instance, Pearson correlation coefficients between the median household income and the percent of brownfields whose cleanup actions have been initiated increases from -0.302 to -0.387 as the radius expands from 0.5 to 1.0 mile (see Table 9-3).

As observed in descriptive analyses, the percent of persons who are not US citizens

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to be assigned' were combined for brownfields whose cleanup actions have not been initiated.

is significantly associated with the percent of cleaned up brownfields within a 0.5 and 1.0 radii from block group centroids. Similarly with other variables, when radius expands from 0.5 to 1.0 mile, stronger association between the percent of persons who are not US citizens and the percent of cleaned up brownfields. For instance, Pearson correlation coefficients between the percent of persons who are not US citizens and the percent of brownfields whose cleanup actions have been initiated increases from -0.090 (within a 0.5 mile radius from block group centroids) to -0.095 (within a 1.0 mile radius from block group centroids) (see Table 9-3). However, such coefficients appear to be marginal compared to other coefficients.

Finally, housing variables also indicate that unstable neighborhoods enjoy brownfield cleanup prioritization (see Table 9-3). For instance, the Pearson correlation coefficient between the percent of brownfields whose cleanup actions have been initiated and the percent of vacant housing units is 0.194 (within a 0.5 mile radius from block group centroids). This means that as the percent of vacant housing units in census block groups increases, the percent of brownfields whose cleanup actions have been initiated within a 0.5 mile radius from block group centroids also increases. Similarly with the rest of variables, when radius expands from 0.5 to 1.0 mile, the same pattern is observed although the strength of correlation coefficients increases to 0.260 (see Table 9-3).

In sum, bi-variate analyses suggest that unexpected racial and socioeconomic disparities of brownfield cleanup prioritization are statistically significant. In other words, impoverished or racially minority neighborhoods are more likely to enjoy brownfield cleanup prioritization. However, the fact that neighborhoods with a higher percent of persons who are not US citizens are less likely to enjoy brownfield cleanup prioritization suggests that brownfield cleanup prioritization might be given to neighborhood with little political power. However, the above associations appear to be marginal. In addition, considering high correlations between political power and socioeconomic characteristics, a mere significant inverse association between the percent of persons who are not US citizens and the percent of cleaned up brownfields is not likely to support the above claim. Rather, because the percent of persons who were not US citizens in 1990 was very low in this tri-county area (1.7%) and because immigrants tend to live close to each other, it is more likely that their residential areas happen to be near

brownfields that are not prioritized for cleanup. Future studies, however, need to probe why neighborhoods which have a higher percent of persons who are not US citizens do not enjoy brownfield cleanup prioritization.

9-2-3 Multivariate Analysis

Bi-variate analyses reveal that all racial and socioeconomic variables are significantly associated with cleanup prioritization of nearby brownfields. However, bi-variate analyses fail to answer which variables are the strongest and independent predictors of the percent of cleaned up brownfields within a 0.5 or 1.0 mile radius from block group centroids. The normality assumption was checked by examining standardized normal plots (displaying standardized predicted values and standardized residuals), and no violation of normality was found. In this regression, the percent of African Americans, the percent of Hispanics, and the percent of vacant housing units of census block groups are found to be independent predictors of the percent of brownfields brownfields whose cleanup actions have been initiated within a 0.5 mile radius from block group centroids when controlling for other variables (see Table 9-4). The percent of African Americans proves to be the strongest predictor of the percent of cleaned up brownfields located within a 0.5 mile radius from block group centroids when controlling for other variables (see Beta in Table 9-4). The percent of persons who were not US citizens in 1990 lost its explanatory power when controlling for other variables. The regression model explains approximately 17% in the variation in the percent of cleaned up brownfields (see R^2 in Table 9-4).

When the radius expands from 0.5 to 1.0 mile radius, the additional three variables of the median household income, the percent of unemployed persons, and the percent of employed persons employed in blue collar occupations become independent predictors of the percent of brownfields whose cleanup actions have been initiated within a 1.0 mile radius from block group centroids when controlling for other variables (see Table 9-4). The percent of African Americans also remains the strongest predictor of the percent of cleaned up brownfields located within a 1.0 mile radius from block group centroids when controlling for other variables (see Beta in Table 9-4). Similar to a 0.5 mile radius, the percent of persons who were not US citizens in 1990 lost its explanatory power when controlling for other variables. As the radius expands from 0.5 to 1.0 mile, the model's

explanatory power increases to 0.249, meaning that the regression model explains approximately 25% in the variation in the percent of brownfields whose cleanup actions have been initiated (see R^2 in Table 9-4).

The above analysis was repeated when cleanup statuses were re-dichotomized. Cleanup statuses of 'completed' and 'in progress' were combined representing cleaned up brownfields while the cleanup statuses of 'not cleaned up' and 'time to be assigned' were combined representing not cleanup brownfields. The three cleanup statuses of 'closed,' 'cancelled,' and 'pending' were excluded. Therefore, the dependent variable became the percent of cleanup brownfields over the sum of cleanup and not cleanup brownfields. The above statistical analyses were repeated for the following reason. Although three cleanup statuses of 'closed,' 'cancelled,' and 'pending' share a common thread with cleanup statuses of 'completed' and 'in progress' which is that cleanup actions have been initiated, these three statuses also differ from the two cleanup statuses which is that cleanup actions have been stopped. Due to this difference, some could argue that brownfields should be dichotomized on the basis of whether cleanup actions have been completed or at least in progress without any interruption. When the above analyses were repeated, virtually identical results were found (see Table 9-5 and 9-6), indicating that including the three clean statuses of 'closed,' 'cancelled,' and 'pending' in the earlier analyses do not substantially alter findings in this chapter.

Results presented in this chapter lead to the conclusion that brownfield cleanup prioritization is given to impoverished and minority neighborhoods. Given that environmental justice studies often find that cleanup prioritization of Superfund National Priority List sites often go to wealthier and whiter neighborhoods (Hamilton 1995; Zimmerman 1993), it has been surprising in this study that brownfield cleanup actions go to brownfield neighborhoods that desperately need both cleanup and redevelopment. There are three possible explanations of why brownfield cleanup prioritization goes to impoverished and minority neighborhoods. First, it is possible that brownfield cleanup prioritization could be given to the most problematic neighborhoods where brownfields are concentrated. Coincidentally, those neighborhoods happen to be impoverished and minority-concentrated. Based on the data in this dissertation, it is unclear whether policy makers are aware of the fact that brownfields tend to be concentrated near

impoverished and minority-concentrated neighborhoods in advance. Future studies thus need to examine whether or not policy makers tend to knowingly give brownfield cleanup prioritization to the above neighborhoods on the basis of racial and socioeconomic characteristics.

Second, if policy makers knowingly give brownfield cleanup prioritization to impoverished and minority-concentrated neighborhoods, it is interesting to investigate how they know brownfields tend to be concentrated near the above neighborhoods. Policy makers might have known because they conducted demographic assessments before cleanup prioritization was decided. Or, environmental justice organizations in the Detroit region might have let policy makers know brownfields tend to be concentrated in impoverished and minority-concentrated neighborhoods and promoted the idea that those areas are needed to be prioritized in cleanups. Lisa Glodstein (2008), the executive director in the Southwest Detroit Environmental Vision, for example, claims that her organization has been involved on brownfield issues for several years. Because examinations of whether organizational efforts contributed to unexpected brownfield cleanup prioritization require a new research design, pinning down it is beyond the scope of this dissertation. Therefore, future studies need to probe what roles environmental justice organizations have played in brownfield cleanup prioritization.

Third, brownfield cleanups tend to be quicker and less expensive than cleanups of Superfund National Priority List sites (Hula 1999, 2002). Brownfield cleanups are not as highly profiled as the Superfund's, and hence local residents might not be aware of brownfield cleanups. Because of local resident's unawareness of brownfield cleanup efforts, little political lobbying might be exercised from interested parties, which enables local and state governments to stick to the original goal of brownfield development. Given that the main goal of brownfield development is to revitalize distressed urban neighborhoods by development of abandoned or underutilized properties (NEJAC 1996; Solitare and Greenberg 2002), brownfield cleanups prioritization could be given to impoverished and minority neighborhoods in accordance with this goal.

There is a limitation in results presented in this chapter. Multivariate linear regression models in this chapter explains approximately 25% variations at best in the percent of brownfields whose cleanup actions have been initiated. This means that

many more variables which are accountable for brownfield cleanup prioritization exist. One important variable is severity of contamination which is not readily available. For the NPL sites, severity of contamination serves as an important criterion in determining cleanup prioritization. Although it is unclear whether scoring schemes in terms of severity of contamination exist for brownfields, it is important to examine whether introducing the above variable (if exist) increase explanation power of regression significantly. In addition, the other important component of brownfield development is developmental potential. In other words, priority of brownfield development at least in the state of Michigan is often given to properties that have high economic developmental potential (Hula 2002; Katz 2002). In this vein, including economic potential is expected to increase explanation power of regression model. Future research thus needs to include the above variables to probe whether brownfield cleanup prioritization still goes to impoverished and minority neighborhoods even when controlling for those two variables. Regardless of the above limitations, it is exciting to find that brownfield cleanup prioritization tend to be given to historically marginalized neighborhoods. The next and critical step that brownfield development policies should take is to offer direct economic benefits to local residents who tend to be impoverished and minorities from brownfield development. The next chapter will summarize the findings in this dissertation, present their academic and policy implications, and propose future research agendas.

Table 9-1 Descriptive statistics of neighborhoods within a 0.5 mile radius from brownfields by cleanup statuses in 1990 by employing centroid containment method

	All brownfields (N=355) (a)			Cleanup actions have been completed or in progress (N=153) (b)			Cleanup actions have not been initiated (N=168) (c)			Cleanup actions have been stopped[a] (N=34) (d)		
	N	Mean	STDEV	N	Mean	STDEV	N	Mean	STDEV	N	Mean	STDEV
Racial Variables												
%Non-Hispanic Whites	1103	41.8%	41.0%	572	30.2%	36.0%	615	51.4%	41.5%	172	30.5%	39.3%
%African Americans	1103	54.6%	42.9%	572	65.8%	39.1%	615	45.3%	42.7%	172	65.9%	41.0%
%Hispanics	1103	2.4%	7.1%	572	3.1%	8.5%	615	1.8%	4.1%	172	2.8%	9.3%
Socioeconomic Variables												
%Female-head Families with Dependent Children	1101	16.1%	12.8%	570	18.6%	12.6%	613	13.4%	12.2%	171	18.5%	13.2%
%Unemployed Person	1099	18.5%	14.3%	568	22.0%	14.9%	612	15.2%	12.5%	171	22.3%	14.4%
%Households with Public Assistance	1101	22.5%	16.6%	570	27.2%	15.7%	613	18.6%	16.1%	171	28.2%	16.6%
%Persons below Poverty	1101	26.6%	19.1%	570	32.7%	18.7%	613	22.2%	18.3%	171	31.0%	18.5%
Average Household Income	1124	$27,883	$14,583	570	$24,889	$11,822	613	$31,048	$15,479	171	$26,314	$14,127
Average Owner-Occupied Housing Value	1101	$39,700	$31,185	541	$30,853	$20,969	575	$45,026	$33,895	162	$37,365	$35,430
%Less than High School Diploma	1103	36.6%	15.8%	572	40.4%	15.9%	615	33.5%	15.6%	172	40.1%	14.7%
%Bachelor's Degree or Higher	1103	10.1%	12.4%	572	8.4%	10.8%	615	12.2%	14.2%	172	8.1%	9.8%
%White Collar Occupations	1095	8.0%	6.8%	565	6.9%	6.5%	612	8.9%	7.3%	170	7.1%	6.4%
%Blue Collar Occupations	1095	31.5%	13.4%	565	31.8%	13.5%	612	30.5%	13.7%	170	32.3%	11.7%
%Not a Citizen	1103	1.9%	4.2%	572	1.7%	3.6%	615	2.2%	4.6%	172	1.7%	4.3%
Housing Variables												
%Vacant Housing Units	1102	7.4%	8.1%	571	9.2%	9.6%	614	6.7%	8.8%	171	8.3%	7.0%
%Owner-Occupied Housing Units	1101	57.2%	25.7%	570	52.0%	24.2%	613	59.8%	27.8%	171	53.9%	23.9%

[a] Cleanup statuses of ‘cancelled,’ ‘closed,’ and ‘pending’ are combined.

Table 9-2 Descriptive statistics of neighborhoods within a 1.0 mile radius from brownfields by cleanup statuses in 1990 by employing centroid containment method

	All brownfields (N=355) (a)			Cleanup actions have been completed or in progress (N=153) (b)			Cleanup actions have not been initiated (N=168) (c)			Cleanup actions have been stopped[a] (N=34) (d)		
	N	Mean	STDEV	N	Mean	STDEV	N	Mean	STDEV	N	Mean	STDEV
Racial Variables												
%Non-Hispanic Whites	2327	53.4%	42.1%	1344	37.0%	39.3%	1697	57.0%	41.6%	562	25.4%	34.4%
%African Americans	2327	43.0%	43.5%	1344	59.2%	41.6%	1697	39.5%	42.6%	562	70.3%	38.6%
%Hispanics	2327	2.3%	6.2%	1344	2.7%	7.7%	1697	2.1%	5.8%	562	3.6%	10.0%
Socioeconomic Variables												
%Female-head Families with Dependent Children	2324	13.7%	12.6%	1342	17.3%	13.0%	1694	12.9%	12.4%	560	19.7%	12.5%
%Unemployed Person	2322	15.1%	13.3%	1339	19.2%	14.0%	1693	14.1%	12.9%	558	23.5%	14.1%
%Households with Public Assistance	2324	18.2%	16.6%	1342	24.1%	16.5%	1694	16.7%	16.0%	560	29.9%	16.3%
%Persons below Poverty	2324	21.2%	18.9%	1342	28.2%	19.1%	1694	19.7%	18.5%	560	33.9%	18.4%
Average Household Income	2359	$32,593	$18,036	1342	$27,688	$13,083	1694	$34,283	$18,572	560	$24,227	$11,816
Average Owner-Occupied Housing Value	2324	$48,596	$39,417	1292	$36,078	$26,060	1638	$51,652	$41,983	539	$29,979	$25,178
%Less than High School Diploma	2327	32.7%	16.1%	1344	37.4%	16.1%	1697	31.6%	16.0%	562	42.1%	15.3%
%Bachelor's Degree or Higher	2327	12.2%	13.8%	1335	9.3%	11.3%	1690	13.3%	14.8%	556	7.3%	9.0%
%White Collar Occupations	2317	8.8%	7.0%	1335	7.5%	6.7%	1690	9.2%	7.2%	556	6.5%	6.4%
%Blue Collar Occupations	2317	30.4%	13.0%	1344	31.6%	13.0%	1696	29.7%	13.1%	562	32.0%	12.5%
%Not a Citizen	2327	2.2%	4.0%	1344	1.9%	4.2%	1697	2.4%	4.2%	562	1.9%	4.4%
Housing Variables												
%Vacant Housing Units	2326	6.0%	7.2%	1342	7.6%	8.2%	1694	5.8%	7.6%	560	9.4%	9.3%
%Owner-Occupied Housing Units	2324	64.0%	25.8%	1251	57.2%	25.2%	1541	64.9%	26.5%	530	52.1%	22.4%

[a] Cleanup statuses of ‘cancelled,’ ‘closed,’ and ‘pending’ are combined.

Table 9-3 Correlation matrices between racial and socioeconomic characteristics of census block groups and the percent of brownfields whose cleanup actions have been initiated[a] within a 0.5 or 1.0 mile radius from block group centroids

	0.5 mile			1.0 mile		
	N	Pearson	Sig	N	Pearson	Sig
Racial Variables						
Non-Hispanic Whites	1124	-0.330	***	2328	-0.438	***
African Americans	1124	0.310	***	2328	0.419	***
Hispanics	1124	0.100	**	2328	0.090	**
Socioeconomic Variables						
Female-head Household with Dependent Children	1122	0.256	***	2325	0.331	***
Unemployed Person	1120	0.318	***	2323	0.389	***
Households with Public Assistance	1122	0.347	***	2325	0.448	***
Household below Poverty	1122	0.351	***	2325	0.444	***
Median Household Income	1122	-0.302	***	2325	-0.387	***
Median Owner-Occupied Housing Value	1074	-0.278	***	2259	-0.356	***
Less than High School Diploma	1124	0.285	***	2328	0.357	***
Bachelor's Degree or Higher	1124	-0.195	***	2328	-0.252	***
White Collar Occupations	1116	-0.181	***	2318	-0.233	***
Blue Collar Occupations	1116	0.070	*	2318	0.116	***
Not a Citizen	1124	-0.090	**	2328	-0.095	**
Housing Variables						
Vacant Housing Units	1123	0.194	***	2327	0.260	***
Owner-Occupied Housing Units	1122	-0.187	***	2325	-0.302	***

* $p > 0.05$ ** $p > 0.01$ *** $p > 0.001$

[a] This percent is computed based on the sum of five brownfield cleanup statuses of ‘completed,’ ‘in progress,’ ‘cancelled,’ ‘closed,’ and ‘pending’ divided by number of all brownfields.

Table 9-4 Linear regression between racial and socioeconomic characteristics of census block groups and the percent of brownfields whose cleanup actions have been initiated[a] within a 0.5 or 1.0 mile radius from block group centroids

	0.5 mile (N=1017)			1.0 mile (N=2228)		
	B	Beta	Sig	B	Beta	Sig
Constant	0.162			0.252		***
Racial Variables						
%African Americans	0.230	0.215	***	0.297	0.309	***
%Hispanics	0.959	0.145	***	0.854	0.126	***
Socioeconomic Variables						
%Female-head Household with Dependent Children	0.072	0.020		-0.119	-0.036	
%Unemployed Person	0.292	0.085	*	0.286	0.087	**
%Median Household Income ($1000)	-0.002	-0.056		-0.002	-0.076	*
%Less than High School Diploma	0.195	0.067		0.167	0.064	*
%Blue Collar Occupations	0.141	0.041		0.163	0.051	*
%Not US Citizens	-0.535	-0.048		-0.341	-0.033	
Housing Variables						
%Vacant Housing Units	0.672	0.110	**	0.487	0.076	**
%Owner-Occupied Housing Units	0.103	0.057		-0.020	-0.013	
R^2		0.168	***		0.249	***

* p > 0.05 ** p > 0.01 *** p > 0.001

[a] This percent is computed based on the sum of five brownfield cleanup statuses of 'completed,' 'in progress,' 'cancelled,' 'closed,' and 'pending' divided by number of all brownfields.

Table 9-5 Correlation matrices between racial and socioeconomic characteristics of census block groups and the percent of cleaned up brownfields[a] within a 0.5 or 1.0 mile radius from block group centroids

	0.5 mile			1.0 mile		
	N	Pearson	Sig	N	Pearson	Sig
Racial Variables						
Non-Hispanic Whites	1025	-0.337	***	2240	-0.427	***
African Americans	1025	0.314	***	2240	0.410	***
Hispanics	1025	0.114	**	2240	0.088	***
Socioeconomic Variables						
Female-head Household with Dependent Children	1023	0.257	***	2237	0.313	***
Unemployed Person	1021	0.318	***	2235	0.372	***
Households with Public Assistance	1023	0.340	***	2237	0.427	***
Household below Poverty	1023	0.361	***	2237	0.430	***
Median Household Income	1023	-0.314	***	2237	-0.376	***
Median Owner-Occupied Housing Value	976	-0.314	***	2173	-0.376	***
Less than High School Diploma	1025	0.282	***	2240	0.340	***
Bachelor's Degree or Higher	1025	-0.185	***	2240	-0.239	***
White Collar Occupations	1018	-0.188	***	2230	-0.217	***
Blue Collar Occupations	1018	0.060		2230	0.105	***
Not a Citizen	1025	-0.092	**	2240	-0.102	***
Housing Variables						
Vacant Housing Units	1024	0.205	***	2239	0.251	***
Owner-Occupied Housing Units	1023	-0.200	***	2237	-0.290	***

* $p > 0.05$ ** $p > 0.01$ *** $p > 0.001$

[a] This percent is computed based on the number of cleaned up brownfields divided by the sum of the number of cleaned up and not cleaned up brownfields. This means that brownfields whose cleanup statuses are ‘pending,’ ‘closed,’ and ‘cancelled’ are excluded.

Table 9-6 Linear regression between racial and socioeconomic characteristics of census block groups and the percent of cleaned up brownfields[a] within a 0.5 or 1.0 mile radius from block group centroids

	0.5 mile (N=1017)			1.0 mile (N=2228)		
	B	Beta	Sig	B	Beta	Sig
Constant	0.137			0.248		***
Racial Variables						
%African Americans	0.250	0.232	***	0.298	0.312	***
%Hispanics	1.153	0.167	***	0.864	0.128	***
Socioeconomic Variables						
%Female-head Household with Dependent Children	0.039	0.011		-0.161	-0.048	
%Unemployed Person	0.256	0.074		0.246	0.074	*
%Median Household Income ($1000)	-0.003	-0.076		-0.002	-0.087	*
%Less than High School Diploma	0.170	0.057		0.146	0.056	
%Blue Collar Occupations	0.117	0.034		0.141	0.044	
%Not US Citizens	-0.484	-0.043		-0.436	-0.042	
Housing Variables						
%Vacant Housing Units	0.715	0.119	**	0.471	0.075	**
%Owner-Occupied Housing Units	0.101	0.057		-0.016	-0.010	
R^2		0.178	***		0.235	***

* p > 0.05 ** p > 0.01 *** p > 0.001

[a] This percent is computed based on the number of cleaned up brownfields divided by the sum of the number of cleaned up and not cleaned up brownfields. This means that brownfields whose cleanup statuses are ‘pending,’ ‘closed,’ and ‘cancelled’ are excluded.

CHAPTER 10: CONCLUSION

This dissertation posed three research questions. They are (1) whether brownfields are disproportionately located near impoverished and minority neighborhoods, (2) whether the presence of brownfields is associated with socioeconomic declines in nearby neighborhoods, and (3) whether brownfield cleanup prioritization is associated with racial and socioeconomic conditions of nearby neighborhoods. It is important to answer those questions first because currently few studies exist examining the environmental justice implications of brownfield and brownfield development. Furthermore, if racial and socioeconomic disparities in brownfield locations exist, then their explanation requires new theoretical perspectives. In other words, theoretical frameworks of locational disparities of hazardous waste facilities in terms of racial and socioeconomic characteristics in existing environmental justice literature limitedly offer explanations of why brownfields tend to be disproportionately located in impoverished and minority neighborhoods due to critical differences between brownfields and hazardous waste facilities. Those differences will be discussed in the next section.

In addition to provision of new theoretical explanations, answering the third research question of brownfield cleanup prioritization is important because cleaning up contaminated properties is the first step of brownfield development. After those properties are cleaned up, then these can be redeveloped. However, there is no study answering whether brownfield cleanup prioritization is associated with racial and socioeconomic conditions of nearby neighborhoods. Answering this question thus provides an initial assessment of the success of brownfield development through the perspective of environmental justice. Having stated the importance of research questions posed in this dissertation, this chapter reviews theoretical framework, the major findings, and limitations of this dissertation. This chapter also discusses academic and policy implications from the findings, followed by future research agendas.

10-1 Summary of Theoretical Framework, Findings, and Limitation

One of the contributions of this dissertation is that it is the first to propose theoretical

explanations to the field of environmental justice as to why brownfields are located in impoverished and minority neighborhoods. Although theoretical frameworks exist to explain why hazardous waste and polluting industrial facilities tend to be located in impoverished and minority neighborhoods in the environmental justice literature (Mohai and Saha 2007; Saha and Mohai 2005), the above explanations limitedly explain why brownfields tend to be located in impoverished and minority neighborhoods. Three explanations of why hazardous waste and polluting industrial facilities tend to be located in impoverished and minority neighborhoods are widely accepted in the environmental justice literature (Mohai and Saha 2007; Psator et al. 2004; Reingquist 2001; Saha and Mohai 2005). First, rational choice models focus on site-selection of facility owners and residents near these facilities. That is, due to availability of cheap land zoned as industrial purposes near impoverished and minority neighborhoods, facility owners tend to perceive these areas are the most efficient locations for industry. At the same time, because residents tend to perceive the presence of hazardous waste and polluting industrial facilities near their residences as a threat, high-income residents typically whites tend to relocate themselves to other areas up on the siting of such facilities while lower-income residents typically minorities are left behind. Furthermore, the depressing effect of such facilities on property values may make homes more affordable, thus attracting more low-income and minority residents (Saha and Mohai 2005).

Second, sociopolitical models emphasize a lack of political influence of impoverished and minority residents. Due to the weak political influence of residents, siting permits of hazardous waste and polluting industrial facilities tend to be granted near impoverished and minority neighborhoods (Bullard 2000). In addition to the weak political power, governments tend to justify their siting decision on the basis of the economic rationale. Because impoverished and minority residents desperately need employment opportunities, governmental officials often argue that siting those facilities could facilitate economic development of nearby impoverished neighborhoods (Bullard and Wright 1987; Saha and Mohai 2005). Third, racial discrimination models posit that locational disparities of hazardous waste and polluting industrial facilities in terms of race result not only from intentional targeting of minority communities due to racial prejudices and beliefs but because they have also become seen as the “path of least

resistance" (Bullard and Wright 1987). In addition, residential segregation as the results of historic discriminatory practices in education, employment, and housing sectors which limit mobility of minorities likely further concentrate minorities around hazardous cites.

When the above models are applied to racial and socioeconomic disparities of brownfield locations, only racial discrimination models offer a substantial explanation. For rationale choice models, the economic rationale of facility owners may explain why facilities tend to be relocated. For instance, as in the case of siting decision of hazardous waste and polluting industrial facilities, facilities owners might relocate their facilities to other places on the basis of their economic calculus such as availability of cheap land and/or better financial incentive packages offered by other municipalities or states. The difference between brownfields and hazardous waste facilities, however, lies in the fact that whether decisions of facility owners (siting versus relocation) directly introduce environmental burdens on nearby neighborhoods. More specifically, although siting of hazardous waste and polluting industrial facilities directly introduce environmental burdens on nearby neighborhoods, relocation of facilities does not directly introduce environmental burdens on nearby neighborhoods. Rather, environmental burdens on nearby neighborhoods due to relocation are discovered later on, and one possible reason of the environmental burdens is mismanagement of chemical substances when facilities were actively in use. Sociopolitical models also do not substantially offer an explanation of racial and socioeconomic disparities of brownfield locations because no permit is required for facilities to leave one area to other. Therefore, the sociopolitical aspect is not closely relevant to explain why brownfields tend to be disproportionately located near impoverished and minority neighborhoods. In short, in order to understand racial and socioeconomic disparities of brownfield locations, the abandonment decision rather than siting decision is the most important factor.

A brief review of the proposed theoretical framework to explain racial and socioeconomic disparities of brownfield locations in this dissertation is as follows. Deindustrialization coupled with concentration of poverty and residential segregation offer explanations of racial and socioeconomic disparities of brownfield locations. In other words, deindustrialization eliminated manufacturing jobs in inner city neighborhoods, which in turn led to job shortages and joblessness for residents in these

areas (Wilson 1987, 1996). When jobs were relocated, whites and wealthy minorities could follow but impoverished minorities could not follow where jobs disappeared due to residential segregation (Massey and Denton 1993). Therefore, residents in neighborhoods adjacent to abandoned manufacturing facilities began to suffer from pervasive joblessness, which led to concentration of poverty. Moreover, although relatively wealthy minorities were able to move from impoverished inner city neighborhoods to suburbs, they tend to live close to these impoverished and minority-concentrated neighborhoods (Massey and Denton 1993; Morenoff and Sampson 1997). Concentration of poverty in inner city neighborhoods resulted in shrinking local service businesses. Therefore, not only could abandoned manufacturing facilities, what I termed category 1 brownfields in this dissertation, become brownfields, but also abandoned local service businesses such as gas stations could become brownfields, what I termed category 2 brownfields. The emergence of category 2 brownfields resulted from the diminishing purchasing power of local residents who experienced concentration of poverty. In short, while hazardous waste and polluting industrial facilities tend to be sited near already-impoverished and minority-concentrated neighborhoods (Pastor et al. 2001; Saha and Mohai 2005), neighborhoods near brownfields appear to go through socioeconomic declines due to complex social and economic processes (i.e., deindustrialization, concentration of poverty, and residential segregation) and become impoverished and minority-concentrated in later decades. It is important to note that this dissertation did not directly test whether theoretical explanations are accurate because of data limitations. Rather, this dissertation examines whether patterns of changes in racial and socioeconomic differences between brownfield and non-brownfield neighborhoods from 1960 to 2000 are consistent with theoretical explanations offered here. More detailed discussions will be presented later in this section.

A second contribution of this dissertation is that it is the first to examine racial and socioeconomic disparities in brownfield locations at the neighborhood level. Two research questions were asked regarding racial and socioeconomic disparities in brownfield locations. The first question was whether brownfields are located disproportionately in minority and low-income neighborhoods while the second research questions asked whether the presence of brownfields is associated with decline of

socioeconomic conditions in neighborhoods. Specifically, the dissertation probed changes in racial and socioeconomic characteristics between brownfield and non-brownfield neighborhoods from 1960 to 2000. In the environmental justice literature, such longitudinal analyses are rare. Several hypotheses were posed for these research questions. First, given concentration of poverty due to deindustrialization, it was hypothesized that brownfield neighborhoods are more socioeconomically disadvantaged than non-brownfield neighborhoods. Second, given residential segregation in addition to the impoverished conditions of minority populations, it was hypothesized that race is an independent and stronger predictor than income of the locations and numbers of brownfields. Third, given that deindustrialization occurred in the 1960s and concentration of poverty became evident in the 1970s, it was hypothesized that brownfield neighborhoods experienced greater socioeconomic decline than did non-brownfield neighborhoods after 1970.

Findings suggested that all hypotheses are supported. In chapter 6, brownfield neighborhoods were found to be more socioeconomically disadvantaged with higher concentrations of minorities than non-brownfield neighborhoods in 2000. Multivariate analysis also revealed that race is an independent predictor from income of brownfield locations in 2000. In addition, race is a stronger predictor than income of the number of brownfields. In chapter 7 longitudinal analyses from 1960 to 2000 found that socioeconomic conditions of both brownfield and non-brownfield areas improved between 1960 and 1970. However, after 1970 brownfield areas began to decline in socioeconomic conditions while the conditions of non-brownfield areas continued to improve. The above findings are consistent with theoretical explanations offered in this dissertation. That is, the city of Detroit began to lose manufacturing establishments from 1963, and loss of manufacturing establishments means African Americans who possessed lower skill and educational attainment lost their jobs in the manufacturing sector. Considering residential segregation against poor African Americans, they were not able to follow where manufacturing establishments were relocated. Consequently, socioeconomic conditions of neighborhoods near manufacturing establishments that left from the city began to decline in the 1970s, not in the 1960s considering the lag effect.

Because brownfield neighborhoods overall tended to be more socioeconomically

disadvantaged than non-brownfield neighborhoods, the initial socioeconomic conditions in 1970 were controlled to determine whether the initial wealth of neighborhoods affected subsequent racial and socioeconomic changes around brownfields. In chapter 8 census tracts were grouped into four categories ranging from wealthiest to poorest on the basis of 1970 socioeconomic characteristics by means of cluster analyses. Distinctive patterns were found among the four categories. For the most affluent neighborhoods, brownfield neighborhoods experienced greater socioeconomic declines than did non-brownfield neighborhoods between 1970 and 1980. However, no significant declines in brownfield neighborhoods relative to non-brownfield neighborhoods were observed after 1980. For second and third most affluent neighborhoods, brownfield neighborhoods experienced greater socioeconomic declines than did non-brownfield neighborhoods in both the 1970s and 1980s. Only between 1990 and 2000 did brownfield neighborhoods experience greater socioeconomic improvement than did non-brownfield neighborhoods for the second and third most affluent neighborhoods. The varying results for the above three clusters suggest that neighborhoods have different coping abilities based on socioeconomic characteristics to absorb the initial socioeconomic shock from deindustrialization. That is, neighborhoods with higher socioeconomic conditions might have better coping abilities so as to confine the initial socioeconomic shock from deindustrialization in one decade than have neighborhoods with lower socioeconomic conditions. In addition, for second and third affluent census tracts, brownfield neighborhoods experienced greater socioeconomic improvements than did non-brownfield neighborhoods in the 1990s due to the unusual national economic growth in this period. In other words, in the high growth economy, employers tend to hire individuals who possessed low skill and educational attainment. Thus, because residents in brownfield neighborhoods might have gotten economic benefits from the unusual national economic growth in the 1990s, their neighborhoods encountered greater socioeconomic improvement compared to non-brownfield neighborhoods.

For the most impoverished neighborhoods, no distinctive changes in socioeconomic characteristics between brownfield and non-brownfield neighborhoods across the three decades were found. For brownfield neighborhoods, this may be because impoverished neighborhoods might have little room for further socioeconomic declines. In addition, a

study in Chicago neighborhoods, Morenoff and Tienda (1997) finds that no underclass neighborhoods in 1970 became non-underclass in either 1980 or 1990. This study suggests that it is rare for poor neighborhoods became non-poor neighborhoods in later decades. The above might explain why impoverished non-brownfield neighborhoods did not experience socioeconomic improvements in the 1980s and 1990s, which is that non-brownfield neighborhoods in this cluster were too impoverished in 1970 to be improved in subsequent decades. That racial and socioeconomic changes around brownfields vary depending on the initial socioeconomic conditions of the neighborhoods was an unexpected finding of this dissertation warranting further research in the future.

The third and final contribution of this dissertation is that it is the first to examine racial and socioeconomic disparities of brownfield cleanup prioritization. A question of whether brownfield cleanup prioritization is associated with the racial and socioeconomic conditions of nearby neighborhoods was posed. The theoretical framework for this research question comes from the environmental justice literature. Two hypotheses were tested based on this literature. First, based on sociopolitical process and resource mobilization theory, it was hypothesized that brownfield cleanup prioritization goes to neighborhoods that have high socioeconomic characteristics. Second, based on institutionalized discrimination, it was hypothesized that brownfield cleanup prioritization goes to neighborhoods that have a higher proportional presence of whites. Neither hypothesis was supported, meaning that brownfield cleanup prioritization was found to go to socioeconomically disadvantaged neighborhoods with high minority concentrations, which was an unexpected finding. There may be several possible explanations for this finding. First, policy makers might think that areas in which brownfields are concentrated are the most problematic and therefore should receive prompt remedy. Impoverished and minority populations happen to reside in those areas. Second, it is possible that environmental justice organizations might have made efforts to promote the idea that brownfield cleanup prioritization should be given to areas where brownfields tend to be concentrated. Third, a contrasting explanation might be because brownfield cleanup is not as highly profiled as Superfund cleanup, local residents might be unaware of brownfield cleanup actions. Without any political lobbying, policy makers might stick to the goal of brownfield development. Regardless of which

explanation proves to be true, this is an unexpected finding because the literature has built the case that impoverished and minority populations are often excluded from environmental benefits. Thus, the initial step of brownfield development in which contaminated properties are cleaned up is a positive direction. The next positive step would be that economic benefits go to local residents without any unintended consequences (e.g., gentrification) when brownfields are redeveloped, which has not been empirically explored yet.

Despite the above findings, there are several limitations in the data that warrant caution in interpretation of the results. First, although this dissertation developed theoretical frameworks explaining why brownfields tend to be disproportionately located near impoverished and minority neighborhoods, this dissertation did not directly test whether series of events offered here, from deindustrialization in the 1960s to the emergence of category 2 brownfields in the 1980s (see Figure 4-1), are accurate or not. For example, it was not possible to test whether deindustrialization led to the emergence of category 1 brownfields from data used in this dissertation. Therefore, this dissertation finds that patterns of changes in racial and socioeconomic differences between brownfield and non-brownfield neighborhoods from 1960 to 2000 are consistent with theoretical explanations offered in chapter 4. In order to test whether theoretical explanations offered in this dissertation are accurate, more detailed information about brownfields is necessary.

Second, as mentioned in chapter 5, the state of Michigan is still developing its database on brownfields. Many currently not listed in the databases may be discovered. However, this dissertation used the most complete data sets currently available. Based on names of properties, approximately 70% of brownfields in the USTfield database appear to be neighborhood service-oriented facilities (category 2 brownfields) rather than large scale industrial facilities (category 1 brownfields). For the remaining brownfields, it is difficult to know which categories (category 1 or category 2) they could fall due to insufficient information. Thus, the USTfield database lacks known large-scale industrial facilities (category 1 brownfields). Given that the brownfields in USTfield database contain underground storage tanks which are frequently found in service-oriented facilities such as gas statsions, it appears that brownfields in this database might

be category 2.

Third, as also mentioned in chapter 5, the dates of abandonment of industrial sites were also not available thus making it difficult to determine the exact timing of socioeconomic decline around such sites. Although associations were found between the decline in socioeconomic conditions of nearby neighborhoods after 1970 and the presence of category 2 brownfields, determining precisely the time order of facility abandonment and socioeconomic declines requires knowing the dates of abandonment of brownfields and hopefully such data become available in the future. Chapter 4 argued that deindustrialization in the 1960s led to the emergence of category 1 brownfields resulting in a decline in socioeconomic conditions in nearby neighborhoods after 1970. It was further argued that such a decline in turn led to the emergence of category 2 brownfields in the 1970s and the 1980s (see Figure 4-1). Therefore, there is a plausible reason to believe that brownfields in this study appear to be category 2 and it is not likely that these contributed to socioeconomic declines because the results support that brownfield neighborhoods relative to non-brownfield neighborhoods experienced socioeconomic declines after 1970 rather than from 1960. Because of the above two data limitations, this dissertation did not test whether theoretical explanations are accurate.

Fourth, when brownfield cleanup prioritization was examined, two important variables were not included due to their unavailability. They are severity of contamination and developmental potential of brownfields. These have been hypothesized to affect cleanup prioritization. For the National Priority List sites, severity of contamination is one of the factors in deciding cleanup prioritization of such sites. However, it is unclear whether contamination severity scoring schemes exist for brownfields. Moreover, when brownfield cleanup and redevelopment prioritization is determined, developmental potential is another critical component (Hula 2002; Katz 2002). In this vein, future studies need to examine how the racial and socioeconomic disparities in brownfield cleanup prioritization found in this dissertation are related to these two variables.

10-2 Policy Implications

This dissertation provides critical demographic information policy makers need awareness of when developing brownfield development policies. First, residents near

brownfields tend to rely more on local jobs than ones farther from brownfields. For example, 34% of residents in census block groups within a 0.5 mile radius from brownfields live and work in the same zip code areas whereas 23% of residents in census block groups beyond a 0.5 mile radius from brownfields live and work in the same zip code areas (see Table 6-2 in chapter 6). Therefore, brownfield development should provide employment opportunities for local residents. In addition, the low rates of home ownership in neighborhoods adjacent to brownfields raise a concern for future when the process of economic revitalization is realized. In other words, new economic development may well initiate gentrification, the social phenomenon that witnesses the influx of relatively wealthy newcomer populations to inner cities. Because renters are more easily displaced than home owners, low home ownership rates in neighborhoods adjacent to brownfields could produce serious adverse unintended consequences of brownfield development. Thus, policy makers should be cognizant of the adverse side effects, minimizing or eliminating them.

There are reasons why the economic benefits of brownfield development need to be accorded to local residents as impoverished minorities. In the planning field, sustainable development is a hot topic in which many scholars are becoming increasingly interested. Further, most state and city/municipal governments espouse sustainable development. As mentioned in chapter 1, a goal of sustainable development is to balance environmental protection, economic development, and equitable resource distribution (Beatley and Manning 1997; Campbell 1996; Roseland 1998). Brownfield development promotes environmental protection via cleanup of contaminated properties and prevention of suburban sprawl by means of infill development. Brownfield development also promotes economic development via investments in abandoned or underutilized properties. Finally, for brownfield development to promote equitable resource distribution, economic benefits need to go directly to local residents as impoverished minorities. When this end is realized, brownfield development will be an excellent policy tool for accomplishing sustainable development in local levels.

10-3 Future Research Agendas

Several future research topics become evident from this dissertation. First, given the data limitations, although this dissertation establishes associations between changes in

socioeconomic characteristics in neighborhoods and the presence or absence of brownfields, it is not clear whether socioeconomic declines in neighborhoods caused the creation of brownfields. In order to establish causal relationships between the two, dates of abandonment of brownfields are needed. When those data are available, analyses conducted in this dissertation need to be reevaluated. Second, although this dissertation posits that category 1 brownfields, large industrial facilities, were created not because of socioeconomic declines in nearby neighborhoods, but because of deindustrialization, this dissertation does not examine whether this is true or not. In order to prove the above claim, types of brownfields are needed. When those data are available, whether changes in socioeconomic characteristics of neighborhoods do not predict the creation of category 1 brownfields can be examined. If necessary data are not readily available, a new research design can test whether the emergence of category 1 brownfields led to socioeconomic declines in nearby neighborhoods which in turn led to the emergence of category 2 brownfields. More detailed historic examinations of selected brownfields could reveal when they were abandoned and what types of businesses were operating prior to abandonment. Such information could be extracted from close examinations of tax and parcel records, and interviewing local residents appear to be valuable sources leading to such information.

Third, socioeconomic disparities of brownfield locations differ on the basis of socioeconomic conditions of neighborhoods in 1970. Therefore, future studies need to reveal why affluent neighborhoods tend to absorb the initial socioeconomic shock better than less affluent neighborhoods. In addition, why no socioeconomic disparities of brownfield locations are found for impoverished neighborhoods needs to be examined.

Fourth, it is unexpected to find that brownfield cleanup prioritization tends to go to impoverished and minority-concentrated neighborhoods. Why brownfield cleanup prioritization thus goes to such neighborhoods unlike to Superfund cleanup prioritization needs to be investigated. Is this because policy makers know that areas where brownfields are concentrated are impoverished and minority-concentrated? Or, is this because environmental justice organizations in the Detroit region promote the idea that brownfield cleanup prioritization needs to go to areas where brownfields are concentrated? Or, is this because local residents are unaware of brownfield cleanups so

as to fail to impose the political presser to politicians or policy makers? The above questions appear to be keys in answer to why brownfield cleanup prioritization tends to go to impoverished and minority-concentrated neighborhoods. Fifth, future studies need to examine whether racial and socioeconomic disparities in brownfield cleanup prioritization found in this dissertation is maintained even when severity of contamination and developmental potential of brownfields are controlled.

Sixth, it is found that areas that have a high increase in the percent of Hispanics are not located near brownfields. In addition, it is found that neighborhoods that show higher percent of non-US citizens are not likely to enjoy brownfield cleanup prioritization. Although percents of those population segments are small in the study area, those findings suggest necessity of further research. Answers for the above questions can be obtained through detailed historic analyses with respect to settlement patterns of specific population segments. Further, racial disparities of brownfield locations and of brownfield cleanup prioritization are conducted in areas where certain minority groups (e.g., Hispanics and/or Asians) are large enough to draw meaningful conclusions. More broadly, it is necessary to examine whether or not all minorities share similar environmental burdens. If not, why distinctive patterns of environmental burdens are found among different minority groups need to be understood.

In addition to future research questions drawn from this dissertation, there are two critical questions concerning when brownfields are developed. First, as mentioned previously, because residents near brownfields enjoy environmental benefits in the form of brownfield cleanups, investigation as to whether the local residents of such neighborhoods also enjoy economic benefits is necessary. Even if economic benefits are accorded to local residents, the investigation of whether gentrification occurs due to brownfield development is also crucial. If gentrification in fact occurs, an examination of whether residents have been displaced needs conducting.

Second, according to Katz (2002), about 5% of cleaned up brownfields from the Clean Michigan Initiative (for detailed discussion about the Clean Michigan Initiative, see chapter 1) were sold on the real estate market, indicating that environmental contamination might not be a major factor in brownfields that have not been redeveloped. Apparently planners and policy makers naively assume that brownfields will be in

demand once environmental contamination is removed. Given Howland's (2004) contention that obsolete infrastructure in inner city properties is associated with market transactions of environmentally contaminated properties, state and local governments will need to upgrade the infrastructure of inner cities for brownfields to prove competitive in the real estate market. In addition to obsolete infrastructure, the perceived safety of inner cities in which minorities tend to be concentrated could well be a factor in deterring brownfield redevelopment. For example, Sampson and Raudenbush (2004) find that although observed disorder predicts perceived disorder, the racial and socioeconomic composition of neighborhoods matters most in predicting perceived disorder. Per this study, the perceived disorder of neighborhoods adjacent to brownfields in which impoverished and minority populations are concentrated could prove high enough to dissuade developers from investing in brownfields. Future research should thus examine why cleaned up brownfields are not attractive to real estate developers.

In short, this dissertation represents an initial step in undertaking brownfield research from the perspective of environmental justice. One exciting finding herein is that brownfield cleanup prioritization tends to go to impoverished and minority neighborhoods. Nevertheless, many environmental justice issues and concerns with respect to brownfield development presented in the preceding need thorough evaluation. Without close scrutiny, the claim that brownfield development constitutes an effective and efficient tool for the future of the US hazardous waste policy (Fitzgerald and Leigh 2002; Hula 2001; Simon and Winson 2002) will remain doubtful.

APPENDICES

Appendix A: Construction of variables in the 2000 Census

Racial variables

1. Percent of Non-Hispanic whites in 2000: The number of whites (P6) is subtracted by the number of white Hispanics (P7). Then, this number is divided by the total number of persons (P1).
2. Percent of African Americans in 2000: The number of African Americans (P6) is divided by the total number of persons (P1).
3. Percent of Hispanics in 2000: The number of Hispanics (P7) divided by the total number of persons (P1).

Sociopolitical variables

4. Percent of persons who are not US citizens in 2000: The number of foreign born persons who are not US citizens (P21) is divided by the total number of persons (P1)
5. Percent of persons having less than high school diploma in 2000: The number of persons having less than high school diploma (P37) divided by the total population whose age is over 25 (P37).
6. Percent of persons having bachelor's degree or higher in 2000: The number of persons having bachelor, master, or Ph.D. degree (P37) divided by the total population whose age is over 25 (P37).
7. Percent of persons in white collar occupations in 2000: The number of persons employed in managerial, professor, and related occupations (P50) is divided by the total number of employed persons over 16 (P50).
8. Percent of persons in blue collar occupations in 2000: The number of persons employed in construction, extraction, maintenance, production, transportation, and material moving occupations (P50) divided by the total number of employed persons over 16 (P50).
9. Percent of female-headed families with dependent children in 2000: The number of female householders, no husband presence with related children under 18 years (P17) is divided by the total number of families (P37).
10. Percent of unemployed persons in 2000: The number of unemployed persons (P43) divided by total number of persons whose age is over 16 in civilian labor force (P43).
11. Percent of persons below poverty in 2000: The total number of persons below the poverty line (P92) divided by the total number of persons whose poverty status is determined (P92).
12. Percent of households receiving public assistance in 2000: The number of households receiving public assistance income (P64) is divided by the total number of households (P9).
13. Median household income in 1999 (P53).
14. Median housing value for specified owner-occupied units in 1999 (H76)

Housing variables

15. Percent of vacant housing units in 2000: The number of vacant housing units (H6) divided by the total number of housing units (H1).
16. Percent of owner-occupied housing units in 2000: The number of owned occupied housing units (H7) divided by the number of occupied housing units (H6).

Appendix B: Construction of variables in the 1960, 1970, 1980, 1990, and 2000 Census

2000 Census

1. Percent of whites in 2000: The number of whites (P6) is divided by the total number of persons (P1).
2. Percent of African Americans in 2000: The number of African Americans (P6) is divided by the total number of persons (P1).
3. Average family income in 1999: Aggregate family income (P78) is divided by the total number of family (P15).
4. Average housing values in 1999: Aggregate housing value for specified owner-occupied units (H78) is divided by the total number of specified owner-occupied units (H74).
5. Percent of unemployed persons in 2000: The number of unemployed persons (P43) divided by total number of persons whose age is over 16 in civilian labor force (P43).
6. Percent of persons having less than high school diploma in 2000: The number of persons having less than high school diploma (P37) divided by the total population whose age is over 25 (P37).
7. Percent of vacant housing units in 2000: The number of vacant housing units (H6) divided by the total number of housing units (H1).
8. Percent of owner-occupied housing units in 2000: The number of owned occupied housing units (H7) divided by the number of occupied housing units (H6).

1990 Census

9. Percent of whites in 1990: The number of whites (P8) is divided by the total number of persons (P1).
10. Percent of African Americans in 1990: The number of African Americans (P8) is divided by the total number of persons (P1).
11. Average family income in 1989: Aggregate family income (P108) is divided by the total number of family (P22).
12. Average housing values in 1989: Aggregate housing value for specified owner-occupied units (H62) is divided by the total number of specified owner-occupied units (H52).
13. Percent of unemployed persons in 1990: The number of unemployed persons (P70) divided by total number of persons whose age is over 16 in civilian labor force (P77+P70).
14. Percent of persons having less than high school diploma in 1990: The number of persons having less than high school diploma (P57) divided by the total population whose age is over 25 (P57).
15. Percent of vacant housing units in 1990: The number of vacant housing units (H4) divided by the total number of housing units (H1).
16. Percent of owner-occupied housing units in 1990: The number of owned occupied housing units (H8) divided by the number of occupied housing units (H4).

1980 Census

17. Percent of whites in 1980: The number of whites (Table 12) is divided by the total number of persons (Table 15).
18. Percent of African Americans in 1980: The number of African Americans (Table 12) is divided by the total number of persons (Table 15).
19. Average family income in 1979: Aggregate family income (Table 77) is divided by the total number of family (Table 9).
20. Average housing values in 1979: Aggregate housing value for specified owner-occupied units (Table 140) is divided by the total number of specified owner-occupied units (Table 133).
21. Percent of unemployed persons in 1980: The number of unemployed persons (Table 55) divided by total number of persons whose age is over 16 in civilian labor force (Table 65+Table 55).
22. Percent of persons having less than high school diploma in 1980: The number of persons having less than high school diploma (Table 48) divided by the total population whose age is over 25 (Table 48).
23. Percent of vacant housing units in 1980: The number of vacant housing units (Table 11) divided by the total number of housing units (Table 11).
24. Percent of owner-occupied housing units in 1980: The number of owned occupied housing units (Table 97) divided by the number of occupied housing units (Table 11).

1970 Census

25. Percent of whites in 1970: The number of whites (P17) is divided by the total number of persons (P17).
26. Percent of African Americans in 1970: The number of African Americans (P17) is divided by the total number of persons (P17).
27. Average family income in 1969: Aggregate family income (P1) is divided by the total number of family

(P19).

28. Average housing values in 1969: Aggregate housing value for specified owner-occupied units (H1) is divided by the total number of specified owner-occupied units (H52).
29. Percent of unemployed persons in 1970: The number of unemployed persons (P54) divided by total number of persons whose age is over 16 in civilian labor force (P58+P54).
30. Percent of persons having less than high school diploma in 1970: The number of persons having less than high school diploma (P42) divided by the total population whose age is over 25 (P42).
31. Percent of vacant housing units in 1970: The number of vacant housing units (H35) divided by the total number of housing units (H35).
32. Percent of owner-occupied housing units in 1970: The number of owned occupied housing units (H8) divided by the number of occupied housing units (H35).

1960 Census

33. Percent of whites in 1960: The number of whites (Table P-1) is divided by the total number of persons (Table P-1).
34. Percent of African Americans in 1960: The number of African Americans (Table P-1) is divided by the total number of persons (Table P-1).
35. Average family income in 1959: Aggregate family income (Table P-1) is divided by the total number of family (Table P-1).
36. Average housing values in 1959: Aggregate housing value for specified owner-occupied units (H-3) is divided by the total number of specified owner-occupied units (H-3).
37. Percent of unemployed persons in 1960: The number of unemployed persons (P-3) divided by total number of persons whose age is over 16 in civilian labor force (P-3).
38. Percent of persons having less than high school diploma in 1960: The number of persons having less than high school diploma (P-1) divided by the total population whose age is over 25 (P-1).
39. Percent of vacant housing units in 1960: The number of vacant housing units (H-1) divided by the total number of housing units (H-1).
40. Percent of owner-occupied housing units in 1960: The number of owned occupied housing units (H-1) divided by the number of occupied housing units (H-1).

Appendix C: Construction of variables in the 1970, 1980, 1990, and 2000 Census

2000 Census

Racial variables

1. Percent of whites in 2000: The number of whites (P6) is divided by the total number of persons (P1).
2. Percent of African Americans in 2000: The number of African Americans (P6) is divided by the total number of persons (P1).
3. Percent of Hispanics in 2000: The number of Hispanics (P7) divided by the total number of persons (P1).

Socioeconomic variables

4. Percent of persons having less than high school diploma in 2000: The number of persons having less than high school diploma (P37) divided by the total population whose age is over 25 (P37).
5. Percent of persons having bachelor's degree or higher in 2000: The number of persons having bachelor, master, or Ph.D. degree (P37) divided by the total population whose age is over 25 (P37).
6. Percent of persons in white collar occupations in 2000: The number of persons employed in managerial, professor, and related occupations (P50) is divided by the total number of employed persons over 16 (P50).
7. Percent of persons in blue collar occupations in 2000: The number of persons employed in construction, extraction, maintenance, production, transportation, and material moving occupations (P50) divided by the total number of employed persons over 16 (P50).
8. Percent of female-headed families with dependent children in 2000: The number of female householders, no husband presence with related children under 18 years (P17) is divided by the total number of families (P37).
9. Percent of unemployed persons in 2000: The number of unemployed persons (P43) divided by total number of persons whose age is over 16 in civilian labor force (P43).
10. Percent of persons below poverty in 2000: The total number of persons below the poverty line (P92) divided by the total number of persons whose poverty status is determined (P92).
11. Percent of households receiving public assistance in 2000: The number of households receiving public assistance income (P64) is divided by the total number of households (P9).
12. Average family income in 1999: Aggregate family income (P78) is divided by the total number of family (P15).
13. Average housing value for specified owner-occupied units in 1999: Aggregate housing value for specified owner-occupied units (H78) is divided by the total number of specified owner-occupied units (H74).

Housing variables

14. Percent of vacant housing units in 2000: The number of vacant housing units (H6) divided by the total number of housing units (H1).
15. Percent of owner-occupied housing units in 2000: The number of owned occupied housing units (H7) divided by the number of occupied housing units (H6).

1990 Census

Racial variables

1. Percent of whites in 1990: The number of whites (P8) is divided by the total number of persons (P1).
2. Percent of African Americans in 1990: The number of African Americans (P6) is divided by the total number of persons (P1).
3. Percent of Hispanics in 1990: The number of Hispanics (P10) divided by the total number of persons (P1).

Socioeconomic variables

4. Percent of persons having less than high school diploma in 1990: The number of persons having less than high school diploma (P57) divided by the total population whose age is over 25 (P57).
5. Percent of persons having bachelor's degree or higher in 1990: The number of persons having bachelor, master, or Ph.D. degree (P57) divided by the total population whose age is over 25 (P57).
6. Percent of persons in white collar occupations in 1990: The number of persons employed in managerial, professor, and related occupations (P78) is divided by the total number of employed persons over 16 (P77).

7. Percent of persons in blue collar occupations in 1990: The number of persons employed in construction, extraction, maintenance, production, transportation, and material moving occupations (P78) divided by the total number of employed persons over 16 (P77).
8. Percent of female-headed families with dependent children in 1990: The number of female householders, no husband presence with related children under 18 years (P19) is divided by the total number of families (P22).
9. Percent of unemployed persons in 1990: The number of unemployed persons (P70) divided by total number of persons whose age is over 16 in civilian labor force (P77+P70).
10. Percent of persons below poverty in 1990: The total number of persons below the poverty line (P117) divided by the total number of persons whose poverty status is determined (P117).
11. Percent of households receiving public assistance in 1990: The number of households receiving public assistance income (P95) is divided by the total number of households (P5).
12. Average family income in 1989: Aggregate family income (P108) is divided by the total number of family (P22).
13. Average housing values in 1989: Aggregate housing value for specified owner-occupied units (H62) is divided by the total number of specified owner-occupied units (H52).

Housing variables

14. Percent of vacant housing units in 1990: The number of vacant housing units (H4) divided by the total number of housing units (H1).
15. Percent of owner-occupied housing units in 1990: The number of owned occupied housing units (H8) divided by the number of occupied housing units (H4).

1980 Census

Racial variables

1. Percent of whites in 1980: The number of whites (Table 12) is divided by the total number of persons (Table 15).
2. Percent of African Americans in 1980: The number of African Americans (Table 12) is divided by the total number of persons (Table 15).
3. Percent of Hispanics in 1980: The number of Hispanics (Table 14) divided by the total number of persons (Table 15).

Socioeconomic variables

4. Percent of persons having less than high school diploma in 1980: The number of persons having less than high school diploma (Table 48) divided by the total population whose age is over 25 (Table 48).
5. Percent of persons having bachelor's degree or higher in 1980: The number of persons having bachelor, master, or Ph.D. degree (Table 48) divided by the total population whose age is over 25 (Table 48).
6. Percent of persons in white collar occupations in 1980: The number of persons employed in managerial, professor, and related occupations (Table 66) is divided by the total number of employed persons over 16 (Table 65).
7. Percent of persons in blue collar occupations in 1980: The number of persons employed in construction, extraction, maintenance, production, transportation, and material moving occupations (Table 66) divided by the total number of employed persons over 16 (Table 65).
8. Percent of female-headed families with dependent children in 1980: The number of female householders, no husband presence with related children under 18 years (Table 20) is divided by the total number of families (Table 9).
9. Percent of unemployed persons in 1980: The number of unemployed persons (Table 55) divided by total number of persons whose age is over 16 in civilian labor force and (Table 65+Table 55).
10. Percent of persons below poverty in 1980: The total number of persons below the poverty line (Table 91) divided by the total number of persons whose poverty status is determined (Table 91).
11. Percent of households receiving public assistance in 1980: The number of households receiving public assistance income (Table 71) is divided by the total number of households (Table 10).
12. Average family income in 1979: Aggregate family income (Table 77) is divided by the total number of family (Table 9).
13. Average housing values in 1979: Aggregate housing value for specified owner-occupied units (Table 140) is divided by the total number of specified owner-occupied units (Table 133).

Housing variables

14. Percent of vacant housing units in 1980: The number of vacant housing units (Table 11) divided by the total number of housing units (Table 11).
15. Percent of owner-occupied housing units in 1980: The number of owned occupied housing units (Table 97) divided by the number of occupied housing units (Table 11).

1970 Census

Racial variables

1. Percent of whites in 1980: The number of whites (P17) is divided by the total number of persons (P17).
2. Percent of African Americans in 1980: The number of African Americans (P17) is divided by the total number of persons (P17).
3. Percent of Hispanics in 1980: The number of Hispanics (P24) divided by the total number of persons (P17).

Socioeconomic variables

4. Percent of persons having less than high school diploma in 1980: The number of persons having less than high school diploma (P42) divided by the total population whose age is over 25 (P42).
5. Percent of persons having bachelor's degree or higher in 1980: The number of persons having bachelor, master, or Ph.D. degree (P42) divided by the total population whose age is over 25 (P42).
6. Percent of persons in white collar occupations in 1980: The number of persons employed in managerial, professor, and related occupations (P58) is divided by the total number of employed persons over 16 (P62).
7. Percent of persons in blue collar occupations in 1980: The number of persons employed in construction, extraction, maintenance, production, transportation, and material moving occupations (P58) divided by the total number of employed persons over 16 (P62).
8. Percent of female-headed families with dependent children in 1980: The number of female householders, no husband presence with related children under 18 years (P19) is divided by the total number of families (P19).
9. Percent of unemployed persons in 1980: The number of unemployed persons (P54) divided by total number of persons whose age is over 16 in civilian labor force and (P62+P54).
10. Percent of persons below poverty in 1980: The total number of persons below the poverty line (P83+P89) divided by the total number of persons whose poverty status is determined (P17).
11. Percent of households receiving public assistance in 1980: The number of households receiving public assistance income (P80) is divided by the total number of households (P19).
12. Average family income in 1979: Aggregate family income (P1) is divided by the total number of family (P19).
13. Average housing values in 1979: Aggregate housing value for specified owner-occupied units (H1) is divided by the total number of specified owner-occupied units (H52).

Housing variables

14. Percent of vacant housing units in 1980: The number of vacant housing units (H35) divided by the total number of housing units (H35).
15. Percent of owner-occupied housing units in 1980: The number of owned occupied housing units (H8) divided by the number of occupied housing units (H35).

Appendix D: Construction of variables in the 1990 Census

Racial variables

1. Percent of Non-Hispanic whites in 1990: The number of whites (P8) is subtracted by the number of white Hispanics (P10). Then, this number is divided by the total number of persons (P8).
2. Percent of African Americans in 1990: The number of African Americans (P6) is divided by the total number of persons (P1).
3. Percent of Hispanics in 1990: The number of Hispanics (P10) divided by the total number of persons (P1).

Socioeconomic variables

4. Percent of persons who are not US citizens in 1990: The number of foreign born persons who are not US citizens (P42) is divided by the total number of persons (P1)
5. Percent of persons having less than high school diploma in 1990: The number of persons having less than high school diploma (P57) divided by the total population whose age is over 25 (P57).
6. Percent of persons having bachelor's degree or higher in 1990: The number of persons having bachelor, master, or Ph.D. degree (P57) divided by the total population whose age is over 25 (P57).
7. Percent of persons in white collar occupations in 1990: The number of persons employed in managerial, professor, and related occupations (P78) is divided by the total number of employed persons over 16 (P77).
8. Percent of persons in blue collar occupations in 1990: The number of persons employed in construction, extraction, maintenance, production, transportation, and material moving occupations (P78) divided by the total number of employed persons over 16 (P77).
9. Percent of female-headed families with dependent children in 1990: The number of female householders, no husband presence with related children under 18 years (P19) is divided by the total number of families (P22).
10. Percent of unemployed persons in 1990: The number of unemployed persons (P70) divided by total number of persons whose age is over 16 in civilian labor force (P77+P70).
11. Percent of persons below poverty in 1990: The total number of persons below the poverty line (P117) divided by the total number of persons whose poverty status is determined (P117).
12. Percent of households receiving public assistance in 1990: The number of households receiving public assistance income (P95) is divided by the total number of households (P5).
13. Median household income in 1989 (P80).
14. Median housing value for specified owner-occupied units in 1989 (H61)

Housing variables

15. Percent of vacant housing units in 1990: The number of vacant housing units (H4) divided by the total number of housing units (H1).
16. Percent of owner-occupied housing units in 1990: The number of owned occupied housing units (H8) divided by the number of occupied housing units (H4).

Appendix E: Logistic and linear regression (neighborhoods within and beyond 1.5 mile radius from brownfields)

	Logistic Regression[a] (N=3558)		Linear Regression[b] (N=3558)		
	B		B	Beta	
Constant	.514		0.800		**
Racial Variables					
% African Americans	2.582	***	3.932	0.355	***
% Hispanics	2.775	*	2.882	0.049	***
% Median Household Income ($1000)	-0.022	***	-.008	-0.048	**
% Unemployment Rates	-0.461		4.145	0.071	***
% Poverty	3.896	***	5.639	0.163	***
% Less than High School Diploma	1.620	*	2.790	0.086	***
Housing Variables					
% Vacant Housing Units	-0.898		9.955	0.147	***
% Owner-Occupied Housing Units	0.803	**	-0.455	-0.025	***
Model					
	985.5[c]	***		0.536[e]	***
	3909.3[d]				

* p > 0.05 ** p > 0.01 *** p > 0.001

[a] The dependent variable is the presence or absence of brownfields within 1.5 mile radius of census block group.

[b] The dependent variable is the number of brownfields within 1.5 mile radius of block group centroids.

[c] Chi^2

[d] -2 Log likelihood

[e] R^2

Appendix F: Racial and socioeconomic characteristics of census tracts within and beyond 1.0 mile from brownfields from 1960 to 2000 by using the 50% areal containment method

TRI-County

	Census Tracts within 1.0 mile radius from brownfields					Census Tracts beyond 1.0 mile radius from brownfields				
	1960	1970	1980	1990	2000	1960	1970	1980	1990	2000
% White	79.02%	72.16%	62.34%	56.84%	52.38%	96.17%	97.00%	93.81%	91.39%	86.17%
% African American	20.73%	27.31%	35.85%	40.63%	43.31%	2.61%	2.65%	4.56%	6.08%	9.25%
Average Family Income[a]	$41,699	$55,897	$54,466	$51,869	$58,716	$50,972	$70,641	$73,879	$78,480	$86,868
Average Housing Values[a]	$76,291	$89,731	$86,686	$77,894	$118,459	$92,297	$119,355	$144,230	$140,625	$198,720
% Unemployed Persons	8.80%	6.40%	14.19%	12.57%	8.56%	5.39%	4.48%	8.82%	5.70%	4.01%
% Persons without High School Diploma	63.01%	52.61%	39.23%	30.67%	23.57%	50.30%	39.46%	25.48%	18.24%	13.23%
% Vacant Housing Units	6.33%	4.67%	6.03%	6.53%	7.06%	6.27%	2.83%	3.51%	4.28%	3.98%
% Owner-Occupied Housing Units	64.91%	68.07%	64.51%	61.73%	64.23%	85.10%	82.08%	78.69%	76.46%	78.24%
N	554	589	589	589	589	227	574	574	574	574

[a] Adjusted by 1999 dollar value (5.73, 4,54, 2.29, 1.34 for 1959, 1969, 1979, and 1989 dollar, respectively)

Appendix G: Racial and socioeconomic characteristics of census tracts within and beyond 1.0 mile from brownfields from 1960 to 2000 by using the 50% areal containment method (divided by Detroit and suburbs)

Detroit

	Census Tracts within 1.0 mile radius from brownfields					Census Tracts beyond 1.0 mile radius from brownfields				
	1960	1970	1980	1990	2000	1960	1970	1980	1990	2000
% White	68.49%	53.34%	32.00%	18.83%	12.03%	92.54%	81.46%	57.32%	40.66%	19.81%
% African American	31.20%	45.98%	65.96%	78.48%	83.86%	7.27%	18.09%	40.78%	56.62%	75.62%
Average Family Income[a]	$38,880	$49,278	$43,806	$37,604	$44,767	$48,910	$58,676	$52,807	$47,647	$51,180
Average Housing Values[a]	$71,128	$72,301	$51,765	$37,503	$69,711	$83,509	$82,966	$63,205	$45,536	$84,410
% Unemployed Persons	10.27%	7.42%	19.04%	20.56%	14.34%	6.12%	4.97%	14.34%	14.07%	10.84%
% Persons without High School Diploma	66.73%	58.72%	46.67%	38.72%	31.09%	54.87%	49.98%	38.20%	30.95%	24.85%
% Vacant Housing Units	7.24%	6.20%	8.44%	9.13%	10.73%	3.96%	2.71%	4.35%	5.97%	6.60%
% Owner-Occupied Housing Units	55.96%	60.32%	55.95%	51.08%	53.03%	79.40%	77.48%	74.08%	67.50%	68.52%
N	395	279	279	279	279	40	33	33	33	33

Non-Detroit

	Census Tracts within 1.0 mile radius from brownfields					Census Tracts beyond 1.0 mile radius from brownfields				
	1960	1970	1980	1990	2000	1960	1970	1980	1990	2000
% White	94.36%	92.40%	90.12%	87.92%	82.85%	96.73%	98.47%	96.49%	94.56%	89.85%
% African American	5.46%	7.24%	8.29%	9.69%	12.69%	1.89%	1.19%	1.90%	2.93%	5.57%
Average Family Income[a]	$45,829	$62,859	$63,295	$62,276	$68,096	$51,312	$71,836	$75,371	$80,265	$88,644
Average Housing Values[a]	$81,691	$103,706	$110,795	$99,598	$141,603	$93,704	$122,978	$150,412	$145,914	$203,963
% Unemployed Persons	6.48%	5.31%	10.52%	7.40%	5.08%	5.26%	4.43%	8.46%	5.25%	3.69%
% Persons without High School Diploma	56.88%	45.54%	32.70%	24.77%	18.57%	49.51%	38.32%	24.55%	17.51%	12.67%
% Vacant Housing Units	4.80%	2.75%	3.68%	4.41%	4.45%	6.66%	2.84%	3.44%	4.18%	3.84%
% Owner-Occupied Housing Units	79.50%	77.49%	72.48%	69.97%	71.65%	86.10%	82.58%	79.05%	77.00%	78.73%
N	159	310	310	310	310	187	541	541	541	541

[a] Adjusted by 1999 dollar value (5.73, 4,54, 2.29, 1.34 for 1959, 1969, 1979, and 1989 dollar, respectively)

Appendix H: Changes in numbers of persons by race from 1960 to 2000 by using the 50% areal containment method

Tri-county area

	1960		1970		1980		1990		2000	
	Beyond	With	Beyond	With	Beyond	With	Beyond	With	Beyond	With
White	1,175,193	2,008,689	1,547,532	1,845,247	1,691,284	1,397,131	1,729,073	1,148,676	1,815,542	1,014,258
Black	31,870	526,920	42,243	698,415	82,145	803,570	115,073	821,131	194,925	838,794
N	227	554	574	589	574	589	574	589	574	589

Detroit

	1960		1970		1980		1990		2000	
	Beyond	With	Beyond	With	Beyond	With	Beyond	With	Beyond	With
White	150,467	1,032,492	112,243	706,675	70,550	342,745	45,174	171,126	21,921	100,215
Black	11,821	470,404	24,920	609,262	50,197	706,589	62,913	713,376	83,675	698,782
N	40	395	33	279	33	279	33	279	33	279

Non-Detroit

	1960		1970		1980		1990		2000	
	Beyond	With	Beyond	With	Beyond	With	Beyond	With	Beyond	With
White	1,024,726	976,197	1,435,289	1,138,572	1,620,734	1,054,386	1,683,899	977,550	1,793,621	914,043
Black	20,049	56,516	17,323	89,153	31,948	96,981	52,160	107,755	111,250	140,012
N	187	159	541	310	541	310	541	310	541	310

Appendix I: Racial and socioeconomic changes of cluster 1 census tracts (N=7) within a 0.5 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	99.50%	1.16%	89.91%	14.96%	75.19%	34.65%	65.47%	41.00%
African Americans	0.25%	0.64%	8.61%	14.38%	22.17%	34.31%	30.77%	41.07%
Hispanics	0.37%	0.38%	0.79%	0.47%	1.04%	0.86%	0.92%	0.66%
Socioeconomic Variables								
Female-head Families with Dependent Children	2.68%	2.08%	6.60%	3.86%	6.80%	7.13%	12.10%	13.99%
Unemployed Person	3.46%	0.74%	4.68%	2.43%	3.98%	1.57%	4.80%	4.75%
Households with Public Assistance	0.95%	0.74%	1.92%	1.05%	3.17%	2.57%	5.66%	6.22%
Persons below Poverty	3.37%	2.03%	3.92%	3.30%	4.54%	3.34%	6.86%	7.13%
Average Household Income ($1000)[a]	$92.04	$25.18	$73.56	$21.22	$72.81	$21.16	$79.85	$34.95
Average Housing Value ($1000)[a]	$180.63	$37.23	$246.37	$67.88	$164.09	$58.56	$247.25	$138.03
Less than High School Diploma	20.21%	6.19%	12.26%	5.20%	9.39%	4.74%	8.47%	3.85%
Bachelor's Degree or Higher	31.72%	7.93%	37.05%	12.01%	42.52%	11.97%	45.95%	16.98%
White Collar Occupations	50.39%	8.23%	45.10%	9.45%	49.05%	6.29%	51.64%	13.26%
Blue Collar Occupations	12.15%	4.36%	11.08%	5.55%	10.13%	3.13%	10.79%	5.41%
Housing Variables								
Vacant Housing Units	4.24%	5.02%	2.95%	2.44%	5.62%	4.45%	4.72%	3.24%
Owner-Occupied Housing Units	71.15%	30.77%	60.34%	36.84%	61.84%	35.48%	64.68%	35.49%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Appendix J: Racial and socioeconomic changes of cluster 1 census tracts (N=108) beyond a 0.5 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	98.94%	3.42%	93.73%	11.97%	87.83%	18.40%	80.26%	22.99%
African Americans	0.68%	3.32%	4.06%	11.92%	8.21%	18.65%	13.36%	23.78%
Hispanics	0.78%	0.78%	0.75%	0.58%	1.02%	1.01%	1.60%	1.13%
Socioeconomic Variables								
Female-head Families with Dependent Children	2.28%	1.25%	3.23%	2.13%	3.40%	2.46%	4.46%	4.17%
Unemployed Person	3.01%	0.93%	4.05%	1.50%	3.34%	1.64%	2.80%	1.95%
Households with Public Assistance	0.79%	0.69%	1.60%	1.14%	2.24%	1.90%	2.95%	2.66%
Persons below Poverty	2.60%	1.70%	2.91%	7.44%	2.60%	2.35%	3.20%	2.47%
Average Household Income ($1000)[a]	$107.55	$34.43	$105.41	$32.87	$115.92	$45.86	$115.95	$42.45
Average Housing Value ($1000)[a]	$194.98	$27.87	$170.36	$55.21	$243.26	$98.84	$313.73	$133.03
Less than High School Diploma	16.44%	5.13%	9.69%	5.11%	7.38%	4.29%	6.27%	3.98%
Bachelor's Degree or Higher	33.32%	7.05%	42.86%	9.64%	49.94%	10.82%	55.90%	12.30%
White Collar Occupations	51.38%	6.76%	50.55%	7.67%	54.73%	7.69%	58.53%	8.40%
Blue Collar Occupations	12.62%	4.72%	10.04%	4.23%	7.81%	3.82%	7.78%	4.29%
Housing Variables								
Vacant Housing Units	3.56%	4.13%	4.11%	3.20%	4.83%	3.93%	3.57%	2.96%
Owner-Occupied Housing Units	83.79%	18.35%	82.89%	22.92%	80.29%	23.86%	83.08%	22.72%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Appendix K: Racial and socioeconomic changes of cluster 2 census tracts (N=21) within a 0.5 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	96.78%	7.42%	60.84%	37.07%	46.86%	39.90%	38.19%	39.61%
African Americans	2.65%	7.09%	37.52%	37.41%	51.49%	40.54%	58.92%	40.64%
Hispanics	0.98%	0.84%	1.04%	0.93%	1.07%	1.27%	1.22%	1.59%
Socioeconomic Variables								
Female-head Families with Dependent Children	3.17%	1.02%	12.28%	7.80%	16.60%	9.74%	16.02%	8.80%
Unemployed Person	3.94%	1.12%	11.18%	4.89%	9.93%	5.90%	6.76%	4.07%
Households with Public Assistance	1.63%	0.88%	8.09%	4.90%	10.50%	8.81%	10.63%	8.84%
Persons below Poverty	4.19%	1.41%	8.85%	5.63%	13.80%	11.94%	10.40%	7.58%
Average Household Income ($1000)[a]	$61.58	$10.65	$54.22	$7.94	$52.55	$12.01	$58.81	$14.13
Average Housing Value ($1000)[a]	$103.47	$19.98	$91.37	$34.37	$74.13	$42.39	$123.71	$60.05
Less than High School Diploma	35.16%	5.71%	25.52%	8.97%	20.81%	9.80%	17.24%	8.87%
Bachelor's Degree or Higher	16.08%	5.23%	18.45%	9.20%	21.02%	12.91%	24.17%	14.51%
White Collar Occupations	31.44%	5.60%	29.18%	9.36%	31.71%	11.74%	33.53%	12.43%
Blue Collar Occupations	23.88%	5.63%	23.45%	7.06%	20.38%	6.17%	20.38%	5.54%
Housing Variables								
Vacant Housing Units	1.57%	0.68%	3.10%	2.14%	4.99%	3.27%	4.50%	3.04%
Owner-Occupied Housing Units	78.31%	14.14%	73.00%	17.46%	68.69%	17.91%	69.86%	17.83%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Appendix L: Racial and socioeconomic changes of cluster 2 census tracts (N=307) beyond a 0.5 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	97.68%	11.02%	92.72%	18.97%	88.61%	23.82%	82.19%	27.79%
African Americans	1.99%	10.93%	5.93%	19.00%	9.37%	23.92%	14.10%	28.25%
Hispanics	0.77%	0.96%	0.92%	0.82%	1.20%	1.04%	1.69%	1.36%
Socioeconomic Variables								
Female-head Families with Dependent Children	3.30%	1.53%	5.68%	3.99%	6.25%	5.85%	7.97%	6.79%
Unemployed Person	3.90%	1.56%	7.78%	2.83%	5.54%	2.96%	4.00%	2.61%
Households with Public Assistance	1.39%	0.98%	3.85%	2.59%	4.24%	3.89%	4.68%	3.97%
Persons below Poverty	3.42%	1.49%	3.83%	2.52%	4.86%	4.64%	5.48%	4.92%
Average Household Income ($1000)[a]	$66.58	$8.31	$66.13	$12.94	$66.01	$19.80	$70.45	$24.58
Average Housing Value ($1000)[a]	$123.63	$23.42	$139.16	$49.21	$126.02	$59.12	$173.31	$86.11
Less than High School Diploma	34.84%	6.51%	23.64%	7.20%	17.62%	6.55%	12.80%	5.91%
Bachelor's Degree or Higher	13.28%	5.16%	18.55%	8.72%	22.81%	11.20%	28.32%	13.96%
White Collar Occupations	30.02%	6.04%	30.84%	8.57%	34.85%	9.08%	38.51%	11.85%
Blue Collar Occupations	30.43%	6.66%	24.16%	6.25%	20.09%	5.72%	19.50%	8.28%
Housing Variables								
Vacant Housing Units	2.45%	2.44%	2.82%	2.75%	3.39%	2.72%	2.96%	1.98%
Owner-Occupied Housing Units	85.20%	10.79%	81.89%	14.95%	79.65%	16.39%	79.93%	17.65%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Appendix M: Racial and socioeconomic changes of cluster 3 census tracts (N=107) within a 0.5 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	81.46%	29.45%	61.86%	37.66%	50.01%	40.64%	42.20%	40.26%
African Americans	18.02%	29.44%	36.22%	38.38%	47.01%	41.93%	53.24%	41.98%
Hispanics	1.45%	1.70%	2.27%	3.48%	2.53%	4.88%	4.56%	9.79%
Socioeconomic Variables								
Female-head Families with Dependent Children	6.13%	2.90%	16.27%	9.35%	23.94%	14.01%	23.34%	11.85%
Unemployed Person	5.94%	2.15%	16.03%	5.12%	16.32%	9.26%	11.80%	6.21%
Households with Public Assistance	4.02%	2.11%	14.62%	7.64%	20.82%	12.43%	18.58%	11.10%
Persons below Poverty	7.61%	3.13%	14.39%	8.30%	25.32%	15.22%	21.24%	12.26%
Average Household Income ($1000)[a]	$48.71	$5.92	$43.25	$7.14	$37.28	$9.40	$42.64	$9.62
Average Housing Value ($1000)[a]	$75.28	$13.79	$60.64	$23.17	$46.46	$24.42	$74.01	$32.92
Less than High School Diploma	55.77%	8.75%	44.12%	9.59%	36.18%	9.57%	29.28%	10.74%
Bachelor's Degree or Higher	5.11%	3.09%	6.49%	4.10%	7.45%	5.29%	9.39%	7.10%
White Collar Occupations	15.13%	5.04%	15.88%	5.93%	18.69%	6.33%	19.06%	7.26%
Blue Collar Occupations	40.55%	6.77%	35.13%	7.07%	29.61%	6.18%	28.13%	7.36%
Housing Variables								
Vacant Housing Units	2.68%	1.62%	4.97%	3.08%	5.75%	3.25%	7.37%	4.04%
Owner-Occupied Housing Units	74.49%	13.46%	68.70%	14.88%	60.82%	16.22%	62.09%	15.89%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Appendix N: Racial and socioeconomic changes of cluster 3 census tracts (N=454) beyond a 0.5 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	96.21%	13.29%	89.65%	21.89%	84.81%	27.73%	79.05%	30.36%
African Americans	3.45%	13.27%	8.75%	21.99%	12.86%	27.90%	16.93%	30.80%
Hispanics	1.19%	1.79%	1.59%	2.43%	2.05%	3.79%	3.19%	6.94%
Socioeconomic Variables								
Female-head Families with Dependent Children	4.29%	1.92%	9.08%	6.81%	11.53%	11.04%	12.35%	11.22%
Unemployed Person	5.71%	2.26%	12.00%	4.53%	8.78%	6.10%	6.22%	4.42%
Households with Public Assistance	2.73%	1.72%	7.72%	5.79%	9.01%	9.23%	8.38%	7.96%
Persons below Poverty	5.84%	3.08%	7.46%	6.01%	10.89%	11.41%	10.22%	10.35%
Average Household Income ($1000)[a]	$53.66	$6.00	$54.30	$11.03	$52.77	$15.51	$58.34	$18.77
Average Housing Value ($1000)[a]	$92.97	$19.38	$106.92	$44.10	$92.53	$46.31	$136.31	$63.53
Less than High School Diploma	51.28%	9.06%	34.10%	11.24%	25.84%	10.49%	19.94%	10.65%
Bachelor's Degree or Higher	5.55%	2.80%	10.04%	6.36%	12.11%	8.01%	16.69%	11.50%
White Collar Occupations	17.07%	5.57%	20.31%	7.37%	23.98%	8.43%	27.33%	11.32%
Blue Collar Occupations	42.36%	6.22%	34.16%	6.27%	28.65%	6.33%	26.87%	7.40%
Housing Variables								
Vacant Housing Units	3.41%	3.79%	4.01%	2.98%	4.70%	3.50%	5.11%	3.81%
Owner-Occupied Housing Units	80.95%	11.55%	76.30%	16.54%	72.61%	18.81%	74.31%	19.27%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Appendix O: Racial and socioeconomic changes of cluster 4 census tracts (N=8) within a 1.0 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	29.02%	29.20%	19.88%	24.68%	14.62%	21.46%	11.40%	17.63%
African Americans	70.24%	29.67%	77.27%	28.43%	82.44%	25.62%	84.45%	24.33%
Hispanics	2.62%	5.57%	2.92%	6.89%	2.79%	7.99%	4.60%	13.26%
Socioeconomic Variables								
Female-head Families with Dependent Children	16.91%	5.67%	29.60%	10.45%	32.08%	11.22%	30.95%	12.82%
Unemployed Person	10.44%	3.01%	24.09%	7.63%	27.89%	10.30%	18.28%	8.26%
Households with Public Assistance	14.86%	5.18%	30.46%	8.66%	34.27%	10.53%	28.22%	9.65%
Persons below Poverty	23.21%	7.38%	32.83%	9.56%	42.88%	11.70%	34.67%	10.91%
Average Household Income ($1000)[a]	$36.41	$5.94	$31.27	$8.16	$26.13	$9.44	$33.63	$9.88
Average Housing Value ($1000)[a]	$55.32	$12.95	$45.05	$27.80	$32.89	$18.90	$62.85	$63.67
Less than High School Diploma	67.83%	8.21%	54.57%	11.13%	46.47%	11.70%	36.92%	10.95%
Bachelor's Degree or Higher	3.52%	3.03%	6.31%	8.33%	8.27%	10.85%	8.97%	9.54%
White Collar Occupations	9.93%	5.39%	16.45%	9.89%	20.62%	13.60%	19.88%	11.46%
Blue Collar Occupations	42.90%	6.73%	31.77%	10.25%	23.58%	8.68%	23.73%	9.11%
Housing Variables								
Vacant Housing Units	9.02%	4.67%	11.94%	5.97%	11.83%	6.83%	15.44%	7.94%
Owner-Occupied Housing Units	45.89%	16.79%	40.12%	17.90%	39.00%	17.33%	40.67%	17.43%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Appendix P: Racial and socioeconomic changes of cluster 4 census tracts (N=130) beyond a 1.0 mile radius from brownfields between 1970 and 2000 by the 50% areal containment method

	1970		1980		1990		2000	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Racial Variables								
Non-Hispanic Whites	60.70%	42.81%	52.42%	43.46%	48.71%	43.77%	43.78%	40.85%
African Americans	38.89%	43.02%	44.00%	45.89%	47.49%	46.03%	47.83%	45.30%
Hispanics	2.80%	4.14%	4.40%	5.06%	3.79%	5.02%	10.45%	15.45%
Socioeconomic Variables								
Female-head Families with Dependent Children	14.10%	8.57%	26.35%	12.41%	32.52%	9.67%	30.32%	12.83%
Unemployed Person	8.71%	1.26%	22.47%	6.79%	22.53%	6.51%	13.00%	1.93%
Households with Public Assistance	11.81%	6.22%	27.35%	9.27%	32.44%	7.18%	27.97%	9.28%
Persons below Poverty	18.37%	5.90%	26.80%	9.30%	42.18%	11.57%	31.23%	12.40%
Average Household Income ($1000)[a]	$40.56	$3.96	$35.89	$6.61	$26.96	$4.55	$40.19	$10.42
Average Housing Value ($1000)[a]	$63.58	$21.93	$52.60	$21.00	$40.83	$15.41	$68.36	$33.05
Less than High School Diploma	66.84%	7.35%	57.57%	10.48%	50.68%	10.73%	45.11%	17.32%
Bachelor's Degree or Higher	2.99%	1.88%	4.68%	3.01%	3.71%	2.70%	4.69%	2.26%
White Collar Occupations	8.23%	3.73%	11.43%	4.71%	12.34%	5.02%	11.25%	3.52%
Blue Collar Occupations	44.73%	8.25%	39.81%	9.12%	33.62%	11.00%	31.05%	9.32%
Housing Variables								
Vacant Housing Units	7.55%	6.24%	8.17%	3.49%	8.58%	5.57%	10.99%	6.84%
Owner-Occupied Housing Units	45.83%	14.62%	45.15%	10.96%	40.15%	8.45%	41.61%	11.57%

[a] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Appendix Q: Numbers of persons by race by cluster

Cluster 1 (a)

	Non-brownfield (N=84)				Brownfield (N=31)			
	1970	1980	1990	2000	1970	1980	1990	2000
# Persons	304,494	327,745	355,321	364,526	23,290	23,272	22,774	23,420
# Whites	301,019	307,589	312,846	293,368	23,234	21,289	17,690	15,544
# African Americans	2,191	13,580	28,837	47,481	26	1,664	4,455	6,819

Cluster 2 (b)

	Non-brownfield (N=197)				Brownfield (N=131)			
	1970	1980	1990	2000	1970	1980	1990	2000
# Persons	1,056,874	1,061,497	1,052,534	1,097,772	92,683	90,809	85,033	81,412
# Whites	1,023,871	972,797	921,010	895,156	89,853	53,827	38,614	31,012
# African Americans	29,432	74,664	110,201	159,065	2,311	35,376	45,121	48,141

Cluster 3 (c)

	Non-brownfield (N=281)				Brownfield (N=280)			
	1970	1980	1990	2000	1970	1980	1990	2000
# Persons	1,413,510	1,559,469	1,586,206	1,732,858	459,774	419,755	392,768	376,097
# Whites	1,340,995	1,368,467	1,325,867	1,378,465	369,191	251,278	193,788	159,346
# African Americans	67,253	164,951	221,693	280,206	88,143	159,917	187,233	198,577

Cluster 4[a] (d)

	Non-brownfield (N=42)				Brownfield (N=98)			
	1970	1980	1990	2000	1970	1980	1990	2000
# Persons	245,653	174,594	133,058	118,524	517,291	358,202	260,653	221,877
# Whites	92,111	49,160	35,243	30,033	129,673	51,635	24,643	18,713
# African Americans	152,180	121,867	94,230	80,572	383,708	298,083	228,860	195,081

[a] 1.0 radius from brownfields

Appendix R: Correlation matrix[a] of racial and socioeconomic differences[b] between brownfield and non-brownfield neighborhoods from 1970 to 2000 (Cluster 1 and 2 census tracts)

	Cluster 1 (N=115)			Cluster 2 (N=328)		
	70-80	80-90	90-00	70-80	80-90	90-00
Racial Variables						
%African Americans	0.1237	0.2033 *	0.0969	0.4441 ***	0.2497 ***	0.0648
%Hispanics	0.0344	-0.0915	-0.1739	-0.0122	-0.3516 ***	-0.3782 ***
Socioeconomic Variables						
%Female-head Families with Dependent Children	0.2999 **	-0.0028	0.2630 **	0.3714 ***	0.2118 ***	-0.1350 *
%Unemployed Person	0.0231	0.0019	0.1319	0.2311 ***	0.0928	-0.1626 **
%Households with Public Assistance	0.0276	0.0720	0.1706	0.3234 ***	0.1663 **	-0.0271
%Persons below Poverty	0.0079	0.0311	0.1927 *	0.3411 ***	0.2399 ***	-0.2850 ***
Average Household Income ($1000)[c]	-0.1998 *	-0.1422	0.2972 **	-0.1732 **	-0.1038	0.1408 *
Average Housing Value ($1000)[c]	0.1499	0.0428	0.1499	0.3005 ***	-0.1800 ***	0.3005 ***
%Less than High School Diploma	-0.0583	-0.0383	0.0169	0.0598	0.0693	0.0835
%Bachelor's Degree or Higher	-0.1623	-0.0560	-0.1128	-0.1181 *	-0.0806	-0.0859
%White Collar Occupations	-0.1679	-0.0087	-0.0638	-0.1073 *	-0.0762	-0.0697
%Blue Collar Occupations	0.1010	0.1002	0.0566	0.2266 ***	0.0600	0.0452
Housing Variables						
%Vacant Housing Units	-0.1144	0.1129	0.0311	0.0889	0.1250 *	-0.0070
%Owner-Occupied Housing Units	-0.1227	0.0942	0.0011	-0.0422	-0.0632	0.0242

* p > 0.05 ** p > 0.01 *** p > 0.001

[a] The dependent variable is whether census tracts are located within or beyond a 0.5 mile radius from brownfields.

[b] Difference refers to percentage difference from two time periods (i.e., percentage difference of white between 1970 and 1980 = %white80 - %white70) except for average household income and average housing value. They are computed based on ratio difference between two periods (i.e., percentage difference of average household income between 1970 and 1980 =[income70 - income60]/income60).

[c] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Appendix S: Correlation matrix[a] of racial and socioeconomic differences[b] between brownfield and non-brownfield neighborhoods from 1970 to 2000 (Clusters 3 and 4 census tracts)

	Cluster 3 (N=561)						Cluster 4 (N=139) [c]					
	70-80		80-90		90-00		70-80		80-90		90-00	
Racial Variables												
%African Americans	0.2847	***	0.2099	***	0.0956	*	-0.0317		0.0424		0.0441	
%Hispanics	-0.2901	***	-0.3673	***	-0.3626	***	-0.2323	**	-0.2131	*	-0.2449	**
Socioeconomic Variables												
%Female-head Families with Dependent Children	0.2970	***	0.2621	***	-0.0765		0.0005		-0.0718		0.0062	
%Unemployed Person	0.2878	***	0.2839	***	-0.1784	***	-0.0022		0.0871		-0.0042	
%Households with Public Assistance	0.3678	***	0.2959	***	-0.1288	**	-0.0410		-0.0359		-0.0416	
%Persons below Poverty	0.3356	***	0.3532	***	-0.2135	**	-0.0121		-0.1250		0.0532	
Average Household Income ($1000)[d]	-0.3015	***	-0.0398		0.1760	***	0.0020		-0.0338		0.0320	
Average Housing Value ($1000)[d]	0.1942	***	-0.2682	***	0.1942	***	0.0024		-0.0554		0.0024	
%Less than High School Diploma	0.2591	***	0.0238		-0.0727		-0.0948		-0.0349		-0.0981	
%Bachelor's Degree or Higher	-0.2294	***	-0.1130	**	-0.1744	***	0.0293		0.1149		-0.0089	
%White Collar Occupations	-0.1537	***	-0.0652		-0.1744	***	0.1097		0.0605		0.0030	
%Blue Collar Occupations	0.1731	***	-0.0006		0.0209		-0.1346		-0.0380		0.0579	
Housing Variables												
%Vacant Housing Units	0.1632	***	0.0112		0.1327	**	0.0138		-0.0192		0.0271	
%Owner-Occupied Housing Units	-0.0368		-0.1846	***	-0.0227		-0.0381		0.1119		0.0063	

* p > 0.05 ** p > 0.01 *** p > 0.001

[a] The dependent variable is whether census tracts are located within or beyond a 0.5 or 1.0 mile radius from brownfields.

[b] Difference refers to percentage difference from two time periods (i.e., percentage difference of white between 1970 and 1980 = %white80 - %white70) except for average household income and average housing value. They are computed based on ratio difference between two periods (i.e., percentage difference of average household income between 1970 and 1980 =[income70 - income60]/income60).

[c] Census Tracts within a 1.0 mile radius from brownfields rather than 0.5 mile

[d] Adjusted by 1999 dollar value (4,54, 2.29, 1.34 for 1969, 1979, and 1989 dollar, respectively)

Appendix T: Partial correlation matrix between racial and socioeconomic changes[a] the presence of brownfields from 1970 to 2000 (0.5 mile radius from brownfields)

	Cluster 1		Cluster 2			Cluster 3		
	70-80	90-00	70-80	80-90	90-00	70-80	80-90	90-00
Racial Variables								
%African Americans	–	–	0.2208 ***	0.0800	–	0.0800	-0.0945 *	0.0064
%Hispanics	–	–	–	-0.2805 ***	-0.2358 ***	-0.2022 ***	-0.2425 ***	-0.2326 ***
Socioeconomic Variables								
%Female-head Families with Dependent Children	0.2483 ***	0.1572	0.0454	-0.0134	-0.0516	-0.0555	0.0254	–
%Unemployed Person	–	–	-0.0608	–	-0.0126	-0.0110	0.0400	0.0093
%Households with Public Assistance	–	–	-0.0052	-0.0519	–	0.0505	0.0268	-0.0164
%Persons below Poverty	–	0.1722	0.0331	0.0871	-0.1052	0.0600	0.1067 **	-0.0461
Average Household Income	-0.1639	0.2706 **	-0.0497	–	0.0583	-0.0859 *	–	0.0918 *
Average Owner-Occupied Housing Value	–	–	0.1226 *	0.0156	0.0690	0.0608	-0.1073 *	0.0858 *
%Less than High School Diploma	–	–	–	–	–	0.0430	–	–
%Bachelor's Degree or Higher	–	–	-0.0076	–	–	-0.0013	0.0494	0.0466
%White Collar Occupations	–	–	0.0138	–	–	0.0284	–	-0.0665
%Blue Collar Occupations	–	–	-0.0046	–	–	0.0150	–	–
Housing Variables								
%Vacant Housing Units	–	–	–	0.0661	–	0.0273	–	0.0100
%Owner-Occupied Housing Units	–	–	–	–	–	–	0.0329	–
Number of census tracts	114	114	328	328	328	561	561	561

* p > 0.05 ** p > 0.01 *** p > 0.001

[a] Changes refer to percentage difference from two time periods (i.e., percentage difference of white between 1970 and 1980 = %white80 - %white70) except for average household income and average housing value. They are computed based on ratio difference between two periods (i.e., percentage difference of average household income between 1970 and 1980 =[income70 - income60]/income60).

Appendix U: Abbreviation

BEA	Baseline Environmental Assessment
BRERA	Brownfield Revitalization and Environmental Restoration Act
C4	Campus Coalition Concerning Chester
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CMI	Clean Michigan Initiative
CRCQL	Chester Residents Concerned about Quality of Life
DEGC	Detroit Economic Growth Corporation
GAO	US General Accounting Office
GIS	Geographic Information System
HUD	U.S. Department of Housing and Urban Development
HWI	Hazardous Waste Inventory
LUST	Leaking Underground Storage Tank
MADD	Mother Against Drunk Driving
MDEQ	Michigan Department of Environmental Quality
NCDB	Neighborhood Change Database
NEJAC	National Environmental Justice Advisory Council
NPL	Superfund National Priority List
PMSA	Primary Metropolitan Statistical Area
RCRA	Resource Conservation and Recovery Act
TIGER	Topologically Integrated Geographic Encoding and Referencing
TRI	Toxic Release Inventory
TSDF	Hazardous Waste Treatment, Storage, and Disposal Facilities
UCC	United Church of Christ
USEPA	United States Environmental Protection Agency
USOTA	United States Office of Technology Assessment
USTfield	Underground Storage Tank

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