Final Report
Verifying the Social, Environmental, and Economic Promise of Brownfield Programs

Brownfields Training, Research, and Technical assistant Grants and Cooperative Agreements Program, BFRES-04-02

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EXECUTIVE SUMMARY

1. Introduction

We received a cooperative agreement from the USEPA to develop a transferable methodology to integrate the economic, environmental, and social benefits of brownfield redevelopment. Over the last three years, we have assembled and analyzed data aimed at identifying variables needed to measure economic, environmental, and social benefits of brownfield redevelopment, and the effect of those variables. In the accompanying report, we provide a guide to the data, methodology, and results.

As of 2008, there has been considerable redevelopment in areas where developers can justify reuse based on EPA assistance and market potential. As developers gain experience with these properties, EPA funds for some properties may no longer be needed. However, there are many brownfields that do not meet the market test, but where redevelopment may pass a benefit-cost test when we allow for environmental and social benefits as well as economic benefits.

2. Economic Benefits of Brownfields and Brownfield Redevelopment

We employ the hedonic approach to examine the relationship between property values and the nearest brownfield, or redeveloped brownfield. We obtained two measures of property values for Charlotte, North Carolina: sales values of single-family homes for the period 1990 through 2005 and assessed values for the years 1991, 1998, and 2003. While sales values are preferable because they are market based, they are only available for a subset of houses, and may be a biased sample as they only represent houses that sold during that time period. In particular, they may under-represent houses in less desirable areas, which are precisely the areas of particular interest in this study.

The independent variable of primary interest is distance from the brownfield or brownfield redevelopment. We also include additional brownfield-related variables, such as size of the nearest brownfield, number of brownfields within a specified distance from the site, announced cleanup, whether or not contamination is found, and whether or not there are restrictions on the type of redevelopment. To isolate the effect of these variables, we include standard housing hedonic variables, including number of bedrooms and bathrooms, lot size, and age of the house.

When using assessment values rather than sales data, we find that assessment value increases at a decreasing rate with distance from the brownfield. The magnitude of the effect depends on whether all properties in the sample are included (a two-mile radius), or whether the sample is restricted to one mile or one-half mile, and whether the assessed value is logged or unlogged. Brownfield redevelopment increases assessed value, with the effect diminishing with distance. An increase in the number of brownfields within a specified radius of the property increases assessed value, where the effect is statistically significant, opposite of expectations. The results of brownfield size are mixed.

Brownfields and their redevelopment can affect property values directly, as well as indirectly through changes in neighborhood composition, given different preferences among populations for living near a brownfield or a redeveloped brownfield. As expected, the full effects, which allow for endogeneity, are larger than the direct effects. For a property 0.25 miles from the nearest brownfield, full effects range, depending on the sample of properties included, from $28,000 to $52,000 as the amenity value of not being directly adjacent to the brownfield; direct effects range from $17,000 to $45,000. Development increases value for the same property by $1,038 to $15,843 (the only statistically significant value) for the direct effect and by $5557 to $24,237 for the full effect. Announcement of a cleanup is positive, and diminishes with distance, consistent with expectations. Variables for brownfield density and restrictions on the type of brownfield redevelopment did not have consistent signs. It was harder to find a pattern for the results based on sales values.

3. The Public Health (Environmental) Impacts of Brownfields and their Reclamation

We use the general approach of regressing health measures on distance from the nearest brownfield. We concentrate on short-term indicators—low-birth weight, infant mortality, and birth defects—which are more likely to be discernable given the period of data collection. We do include, however, the long-term indicator of cancer mortality among persons age 45 and older, We categorize sites into three zones: no brownfields in the Census block group or within half-mile of the group; no brownfields within block group, but a portion of the block falls within one-half mile of brownfields; and the Census block contains at least one brownfield (all of these sites fall into one-half mile zones of brownfields outside the block). Initial results show the presence of brownfields (brownfield variables 2 and 3) significantly increase low birth weights. Brownfield variable 2 is positive and significantly related to stillbirths and infant mortality. Brownfield variables do not have a significant effect on birth defects or cancer mortality. When we control for socioeconomic status and demographic variables, however, the relationship between brownfields and negative health indicators disappears.

We also examine the change in health measures from 2000 to 2006, the period when brownfields were cleaned up. There were no statistically significant effects of brownfield cleanup on any health indicator.

Finally, we estimate the number of averted statistical deaths caused by cancer, on the assumption that the cleanup reduced toxic chemicals from previous levels to the EPA standard at which there are negligible health risks. We found that cleanup averted 2.97 cancer incidences. Based on the five-year survival rate of 63%, the cleanup averted 1.87 statistical deaths. Using the EPA value of a statistical life of $6.9 million in 2008 dollars, the brownfield cleanup in Charlotte has generated an economic benefit of $7.59 million in averted cancer deaths. This figure does not include benefits of averting diseases that do not result in death or that cause long periods of disability before death.

4. Social Benefits of Brownfield Reclamation

Charlotte maintains a City-Within-a-City (CWAC) database that includes data on economic, crime, social, educational, and physical appearance variables for neighborhood statistical areas (NSAs) once every two years. Each NSA is ranked on 20 variables and classified as "Fragile," "Transitioning," and "Stable." We combine CWAC data with brownfields data to examine the effects of brownfields and their reclamation on neighborhoods. The dependent variable is a social indicator score for 2006, regressed on the number of brownfields in the neighborhood, the value of the social indicator score in 2000, and a variable for the change in the percentage of students passing the statewide competency exam. The latter variable was included to try to account for the major change in school reassignment between 2006 and 2006.

We begin with an investigation using simple nonparametric correlation analyses. None of the summary variables, and only three of 20 individual variables, showed statistically significant relationships with the presence of brownfields. The available infrastructure and the physical appearance of the neighborhood were negatively associated with brownfields while the availability of public transportation was positively related.

Our regression analyses indicate that the redevelopment of brownfields did not lead to a statistically significant change in either the 20 individual variables or in the summary measures. Finally, we use as a dependent variable the sum of the summary measures. We then regress this variable for 2006 on the variable's value for 2000, the number of brownfields cleaned up in a neighborhood, and the change in the percentage of students passing the state competency exam. Although the sign of the brownfield variable is in the expected direction, the result is not statistically significant. The change in the student competency score is significant at $p<.07$, indicating that the change in school assignment probably had a negative effect on low-income neighborhoods.

5. Policy Implications

The evidence suggests that brownfields have a negative impact on property values and brownfield redevelopment has a positive effect. These findings are in line with expectations that brownfields have negative economic effects and their redevelopment has positive economic effects. In addition to the property value effects of redeveloping brownfields, there are health benefits in the form of averted cancer deaths. There are likely additional health effects from reduced morbidity and disability, which we did not measure. Finally, we expected to find social effects—negative from brownfields and positive from brownfield redevelopment—but did not. While the fragile neighborhood with the greatest number of brownfield redevelopment projects did improve, other neighborhoods with substantial redevelopment did not. It may be that improving the overall quality of life in a neighborhood takes substantial time.

Another possible explanation is that the driving force in Charlotte's brownfield redevelopment program was the market. Developers motivated by profit worked with Charlotte to choose the properties to redevelop. They avoided properties with health and crime issues.

6. Goals Not Achieved in the Project

We originally sought to distinguish empirically among those projects where (a) redevelopment would have occurred in the absence of subsidies, (b) successful redevelopment could only have occurred with government subsidies and the social benefits outweighed the social costs, and (c) redevelopment was unsustainable even with subsidies. We were unable to systematically make these distinctions. The CWAC data were not designed for this task, and the neighborhood changes due to school reassignment may have swamped brownfield effects.

We also set out to develop a methodology that would assist policymakers in determining social effects, allowing for economic, health, and environmental values. As already stated, the CWAC data were not fully adequate for determining social benefits. But even within the economic analysis where we did not use CWAC data, the different outcomes in our hedonic models when using assessment vs. sales data as well as the absence of robust findings from alternative specifications and distances from brownfields or brownfield redevelopment suggest that it would be imprudent to attempt to include indicators across different domains when we are unable to find consistency or significance within a single domain.

7. Ongoing and Future Research

Dr. Peter Schwarz has submitted a paper based on the work in this project (contained in an appendix) to the *Southern Economic Journal.* In brownfield work not directly related to this project, he is analyzing the risk-based approach to brownfield redevelopment, which allows a lower clean-up standard for non-residential redevelopment. He will present his model and simulation at the inaugural meeting of the Society for Environmental Law and Economics at the University of British Columbia in March 2009. He also has a project that uses California data to compare redevelopment for properties subject to CERCLA liability and properties subject to the risk-based approach. The expectation is that the risk-based approach will lead to a lower percentage of residential redevelopment, and a higher percentage of industrial redevelopment.

Drs. Junfeng Wang and Kenneth Godwin are examining the intergovernmental relationships involved when federal, state, and local governments address a past government failure. They will be presenting the results of this paper at the environmental policy section of the Midwest Political Science Association in March 2009. They also are examining whether initiating brownfield projects in areas where market forces are strong and levels of contamination are relatively low is more likely to spur future brownfield development and its associated benefits to low-income populations than initiating projects in more contaminated and more economically distressed areas. They will submit this paper to *Environmental Management.*

Verifying the Social, Environmental, and Economic Promise of Brownfield Programs

1. Introduction

Brownfield redevelopment has gained wide support across the United States. Currently almost all states have brownfield legislation in place. This legislation attempts to correct the problems created by applying Superfund's liability and cleanup provisions to relatively small and lightly polluted urban sites. In the 1990s, the U.S. Environmental Protection Agency (EPA) launched a number of Superfund reforms to encourage the development of brownfield projects. Since then, EPA and other federal agencies have provided resources to simplify and accelerate brownfield redevelopment. The goals of the brownfield initiatives include increasing jobs, improving the tax base, removing threats to health and safety, encouraging smart growth, and improving the quality of life for people living in neighborhoods with brownfield sites.

Since 1996, Charlotte, North Carolina has participated actively in brownfield reclamation projects. The City has received $800,000 in brownfields pilot project funding and loans from the EPA. An important characteristic of Charlotte's situation is that its brownfields are believed to be only lightly polluted when compared with the industrialized cities of the Northeast and Midwest. In addition, because of Charlotte's rapid population and economic growth, there is a need to development abandoned parcels within the urban area to slow down urban sprawl and to encourage smart growth.

EPA funded the University of North Carolina Charlotte (UNCC) research team of Drs. Hunter Bacot[1], Ken Chilton, and Peter Schwarz to develop a nationally replicable methodology that could assess the social, economic and environmental benefits of brownfields redevelopment for low-to-moderate income communities. Among the major goals of the project were: 1) to identify the data that are likely to be available to state and local governments that wish to examine the impacts of brownfields and their reclamation; 2) to provide methodologies for estimating economic, social, and environmental impacts and to indicate the limitations of such analyses; and 3) to identify criteria by which to empirically assess the multi-dimensional impacts of brownfields projects on communities. Appendix 1 lists all variables needed,

Charlotte presents an important opportunity to determine if such a methodology is possible because the city maintains a longitudinal dataset that collects economic, social, and environmental data by neighborhood. This dataset comes from Charlotte's City within a City (CWAC) project. The availability of CWAC data suggested that it might be possible to examine the impacts of brownfields and their reclamation on various economic and noneconomic aspects of neighborhoods. Earlier research by Bacot and Odell (2005) had suggested that brownfield reclamation had a measureable impact on a neighborhood's quality of life. As will

[1] Shortly before the project began, Dr. Bacot left UNC Charlotte and Dr. Kenneth Godwin replaced him on the project.

be discussed below, a major question this report addresses is whether it is possible to measure the impacts of brownfields and their redevelopment in a city that is undergoing rapid change and whose brownfields contain relatively light levels of toxic chemicals.

1.1 The Initiation and Development of Brownfield Programs in Charlotte

In 1996, the Charlotte Brownfield Program started as an EPA brownfield pilot program and received a start-up grant of $200,000. The grant was specifically for the assessment of suspected contaminated sites in the historic South End area of Charlotte. A coalition of local government officials, developers, and environmentalists worked to obtain the EPA pilot grant, introduce and pass the North Carolina Brownfields Property Reuse Act, and create a special tax district to fund ongoing and new initiatives in the South End. Table 1 shows the major brownfield policies and programs affecting the state and the city.

Table 1: State and Local Brownfield Policies

Date	Policy	Aimed impact	Eligible area
1997	The North Carolina Brownfields Property Reuse Act	Create a state brownfields program in which developers and NC Department of Environment and Natural Resources (DENR) enter a brownfield agreement for liability protection; and five years of property tax reduction on the improvements made to the brownfield	NC statewide
City of Charlotte			
1996	Received Brownfields Assessment Demonstration Pilot from the EPA	Create a city brownfield program in which the city provides financial assistance to environmental assessments up to $20,000 per project	South End
1999	City creates a special tax district	Fund ongoing activities in the South End	South End
2000	Received supplemental assistance for the Pilot from the EPA	Continue to provide financial assistance to environmental assessments up to $20,000 per project	All major business corridors

The first brownfields agreement completed in North Carolina was for Camden Square, a site in the South End. The private investment for the Camden Square project is estimated at greater than $15 million. The Camden Square development is a design center that houses studios, showrooms, and offices on a former industrial site.

To qualify for assistance from the Charlotte brownfield program, property owners must be located in Charlotte's Business Services Program Geography (BSPG), a designated geographic area based on, with few exceptions, the city's "City within a City" area. CWAC is a geographical area designated by local planning policy and based on Census boundaries that encompass nearly 75 city neighborhoods (exclusive of the central business district). All commercial, industrial, and development businesses (not residential) located in the BSPG are eligible for program services, which include the city's brownfield program. Properties qualifying for participation in the Charlotte Brownfield Program must demonstrate that "there has been an actual release or substantial threat of a release of hazardous substances."

The Charlotte Brownfield Program is composed of two assistance programs: the Brownfield Assessment Grant Program and the Property Tax Incentives Program for improvements. The Brownfield Assessment Grant Program subsidizes assessment activities, cleanup design costs, and legal expenses. The program provides up to 50% in matching funds (with a $20,000 limit per site) and can be used by commercial, industrial, and development businesses. The Property Tax Incentives Program is authorized by state legislation (see Table 1). The program provides property tax incentives for improvements made to real property enrolled in the brownfields program. The property tax incentive program applies to the first 5 years after completion of improvements; incentives are governed by a sliding scale or a percentage tax abatement, which ranges from 90% to 10% per year.

Charlotte's first brownfield projects were concentrated in The South End (see Figure 1 below). The South End was a particularly good location for initiating the brownfields program for a number of reasons. First, it is located just south of uptown Charlotte, the Carolina Panthers stadium, and the Charlotte Convention Center. A free trolley service connected the South End to uptown locations. Second, the South End brownfield sites were only lightly contaminated and appeared to present no major health hazards. Third, the South End sits at the boundary of the Wilmore neighborhood, a federally designated Enterprise Community, and Dilworth, a wealthy neighborhood. This intersection provided an excellent opportunity for rapid appreciation of real estate values once the liability concerns had been reduced by state legislation.

The South End has attracted $800 million in new investments and employs thousands of people in 386 businesses (Wang 2008). Its success made Charlotte a national example of brownfields cleanup and reuse. Figure 1 shows the location of the South End within the City of Charlotte and the specific locations of the South End brownfield projects while Figure 2 shows the neighborhoods surrounding the South End.

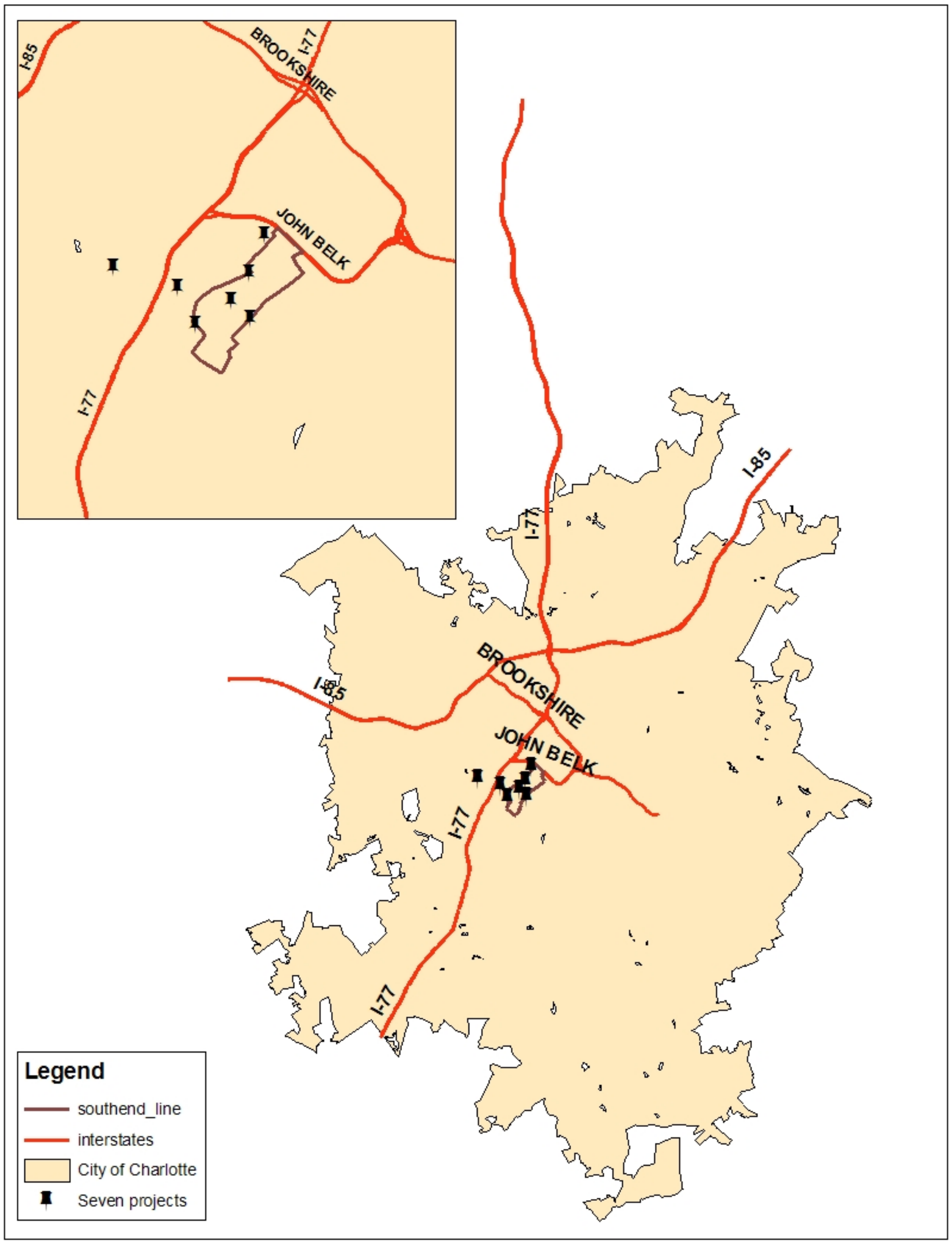


Figure 1: The South End and Its Brownfield Projects

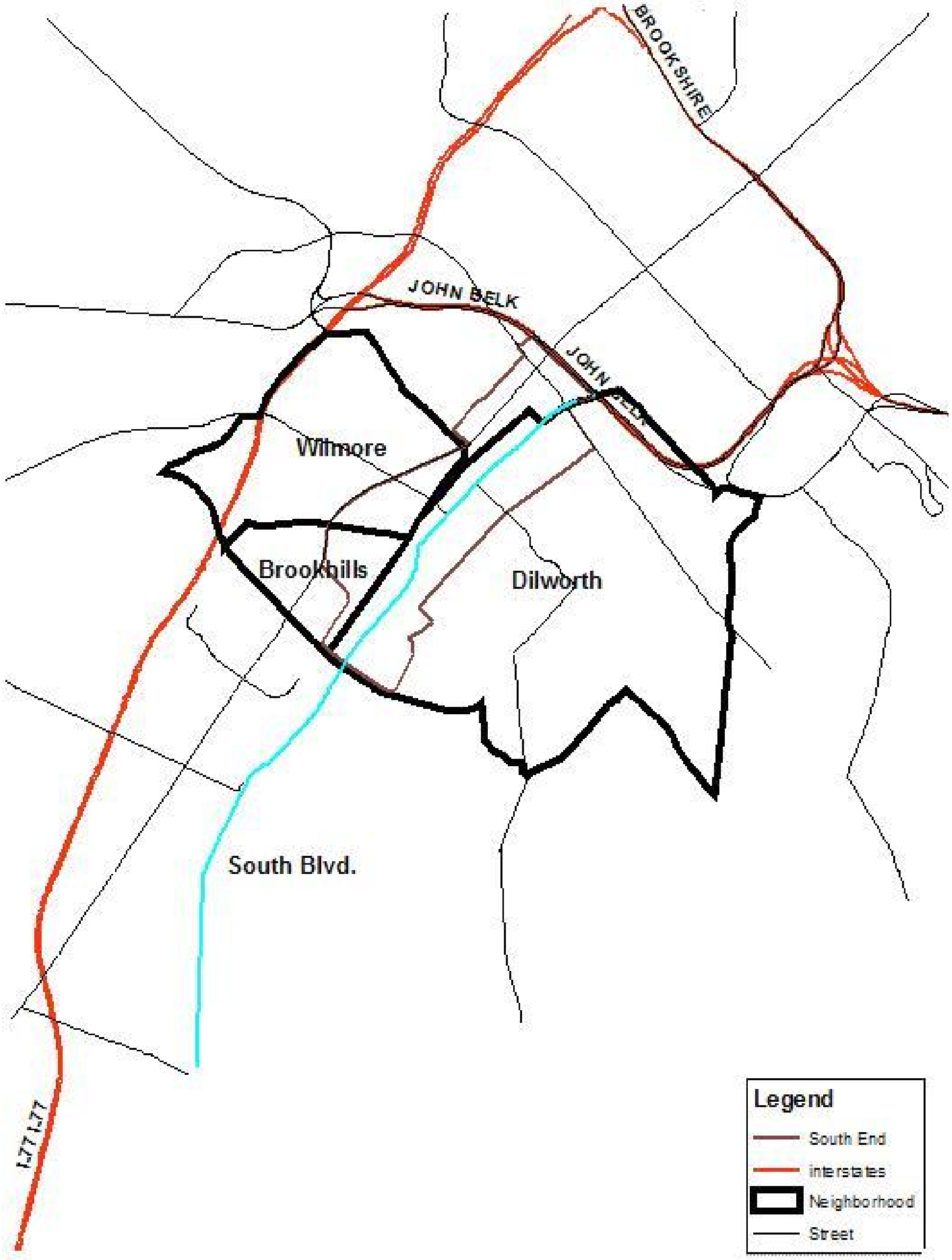


Figure 2: The South End and Its Surrounding Neighborhoods

The success of the South End along with the substantial property tax incentives provided by the state encouraged developers in Charlotte to initiate a substantial number of brownfield projects. By the end of 2004, 39 properties in Charlotte had either signed or had pending brownfield agreements (Bacot and Odell 2005). By 2007 this number had reached 76 (Wang 2008).

1.2 Brownfield Site Selection

Charlotte has taken a different approach to brownfield development than have many cities. Rather than attempting to redevelop sites that are having the greatest negative impacts on neighborhoods, Charlotte has allowed market forces to dictate which brownfields will be developed. For example, Tom Warshauer, the Director of Charlotte's Economic Development Office (the office that manages the Brownfield Program), explained that the City saw the South End as an opportunity to demonstrate the utility of Transit Oriented Development (TOD) and mixed-use, high-density development (MUDD), two of the City's most important planning and development goals. The primary goal of the early projects was to have an economic success. Warshauer and the members of the Brownfield Program Site Selection Committee believed that if the City could demonstrate that brownfield development was profitable, then subsequent developers might be more willing to redevelop sites that presented greater environmental hazards and had less market potential.[2]

The reliance on market forces has continued to characterize the Charlotte brownfields program, and this emphasis has led developers to focus on brownfields located in higher income neighborhoods. For example, the CWAC data classifies neighborhoods into three categories: "stable," "transitioning," and "fragile." The 2000 median household income in stable communities was $48,820, $27,013 in transitioning neighborhoods, and $21,679 in fragile neighborhoods. By 2006, 60% of the sites with brownfield agreements had been cleaned up in stable neighborhoods while only 34% of the brownfields in transitioning and fragile communities had completed cleanup activities. Currently, the primary criterion a project must meet for these grants is that it must be located within the Charlotte Business Corridor Revitalization Geography (Figure 3), a broad area that includes all categories of neighborhoods.

The City published six criteria that would guide the brownfield site selection process:[3]

- The suspected contamination is eligible under EPA grant guidelines
- The contamination is an impediment to redevelopment
- The project's probability of success will increase with environmental issues resolved
- The proposed end-use is consistent with community needs
- Proposed use is consistent with adopted zoning and land-use plans
- All taxes are paid in full.

Notice that there is no priority given to projects in fragile areas or to projects that might alleviate significant health problems. In fact, as Tom Warshauer explained, the initial brownfield projects were selected to avoid areas where toxic wastes might be causing health problems as such problems might have increased costs and delayed project completion.

[2] Interview of Mr. Warshauer on March 9, 2007 with Junfeng Wang and Ken Godwin.
[3] From Charlotte Mayor Patrick McCrory's testimony before the Subcommittee on Water Resources and Environment of the Committee on Transportation and Infrastructure, March 15, 2001

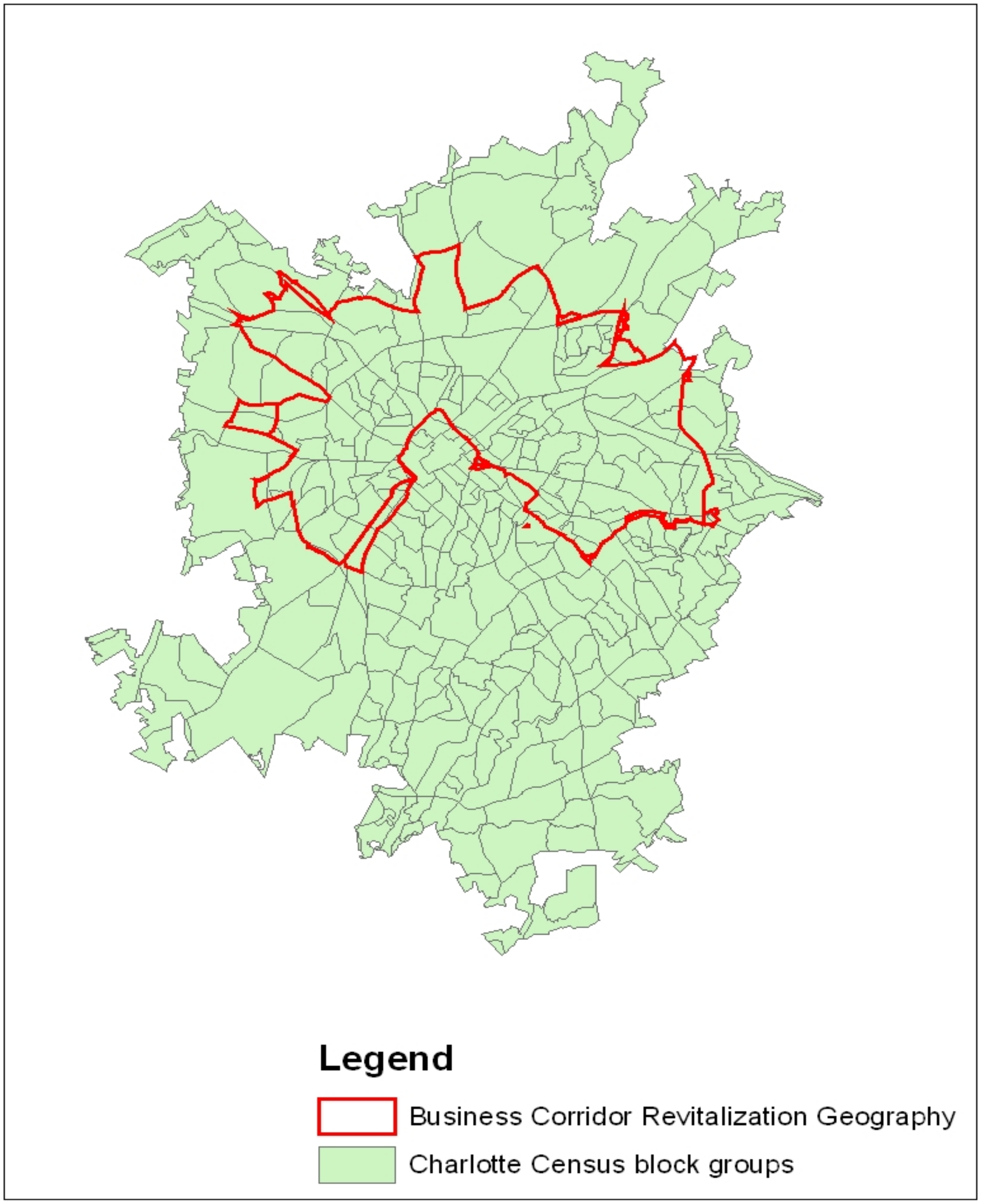


Figure 3: The Area Currently Approved for Brownfield Projects

1.3 Factors Confounding the Analyses in this Study

Three important factors created problems for the analyses reported here. First, the emphasis on choosing projects with the highest market potential and avoiding projects in areas that might present substantial environmental and health risks meant that the impacts of individual brownfield sites and their redevelopment may have been less than would have been the case if sites had been selected based on their negative impacts on the surrounding neighborhoods. Even studies of Superfund sites have had difficulty in discovering statistically significant economic and public health effects related directly to site cleanup (Gallagher and Greenstone. 2006; Noonan, Krupka and Baden 2007a, 2007b). Because the brownfield projects in Charlotte were largely limited to sites with generally low environmental disamenities, this reduced the likelihood of finding measurable economic, social, and health impacts from brownfield reclamation.

The second confounding factor was that Charlotte has large numbers of sites that could be classified as brownfields but are not. Charlotte Mayor Pat McCrory estimates that there are more than 1000 potential brownfield sites in Charlotte.[4] The 76 projects in the Charlotte Brownfield Program are just a beginning of the brownfield redevelopment process. In consultation with the EPA, we agreed to focus exclusively on the sites that have been declared brownfields. While exclusion of other sites with actual or potential contamination can bias the results due to omitted variables, there is no bright line as to what properties to include if going beyond recognized brownfields. For example, underground storage tanks are typically not categorized as brownfields, but are likely to have similar effects. But the inclusion of all contaminated sites, of which underground storage tanks, leaking and otherwise, are just one category, could dwarf the number of brownfields, making it impossible to isolate the effects of the brownfield designationIn some parts of the research we have attempted to control for the effects of other sites, but, as we will discuss in the analysis sections, we are unable to completely control for their impacts.

A change in school assignment policy was the third factor that introduced problems for our analyses. All case studies are potentially subject to exogenous shocks that may change the environment of a study. This event occurred in Charlotte. Charlotte Mecklenburg Schools (CMS), the consolidated public school district that includes all of Charlotte and Mecklenburg County, changed its assignment policy in 2002 from one that used busing to achieve racial balance to a system where students were assigned to their neighborhood school. This negatively affected the desirability of low-income neighborhoods because children residing in these neighborhoods no longer attended schools with balanced racial and socioeconomic student bodies. Instead, the students were assigned to schools with very high concentrations of minority and low-income students. This had a substantial impact on house prices in low-income areas. As Kane, Riegg, and Staiger found in their 2006 study of CMS schools and housing prices, housing prices are quite sensitive to changes in the makeup of a school's

[4] From Charlotte Mayor Patrick McCrory's testimony before the Subcommittee on Water Resources and Environment of the Committee on Transportation and Infrastructure, March 15, 2001

student body. This school reassignment may have attenuated the economic benefits of brownfield cleanups in low- and moderate-income neighborhoods.

1.4 Summary

For what might be called a "post-industrial city," brownfield redevelopment in Charlotte has been extensive. The vast majority of the city's abandoned urban sites are lightly polluted when compared to the rust-belt cities of the Northeast and Midwest. In addition, the strong demand for land in the Charlotte metropolitan area has encouraged developers to look at abandoned and underutilized sites. Once the North Carolina State Legislature alleviated most of the liability concerns of developers by passing the North Carolina Brownfields Property Reuse Act, Charlotte's brownfield program took off. The economic success of the South End further encouraged brownfield development. However, Charlotte did not choose brownfield sites to develop and then go look for developers. Instead, Charlotte allowed market forces to dictate which abandoned and underutilized sites would be developed first. This procedure has led to the selection of sites with greater market potential and generally less pollution and fewer environmental disamenities. We now turn to the separate analyses of the economic, health, and social impacts of Charlotte's brownfields program.

2. Economic Benefits: Doing a Hedonic Study of Brownfields and Brownfield Redevelopment

2.1 Hedonic Study Approach

The hedonic approach, as applied to environmental issues such as brownfields, examines the effect of an environmental factor on property values, while holding constant other characteristics that also affect property values. Recently, a limited number of hedonic studies have estimated the impact of brownfields and an even smaller set of studies have estimated the impacts of brownfield redevelopment. The impacts of redevelopment are particularly difficult to measure as redevelopment is recent and property values may adjust gradually. The data may also make it difficult to unbundle the effects of the stages of redevelopment such as the announcement of cleanup, the actual cleanup, and redevelopment.

There are also studies of more severely contaminated Superfund properties. We would expect these studies to clearly show that the presence of a Superfund property reduces property values and that their cleanup would increase property values. The results, however, have been mixed. These mixed results have thrown into question the cost effectiveness of cleaning up Superfund sites. Given the lack of robustness of findings for severely contaminated properties, investigators of brownfields should not assume that brownfields will necessarily reduce property values or that redevelopment will increase them. In fact, we might find that because people may be unaware of nearby brownfields until brownfield announcements, the short-term impact of a brownfield agreement is a reduction in property values created by stigma effects. Property values also may change because of exogenous shocks such as the change in school assignment policies, increases in crime rates, or changes in the surrounding infrastructure.

Another potential exogenous shock would be the redevelopment of contaminated properties in Charlotte that have not entered into a brownfield agreement with the State of North Carolina. Our research concentrates on brownfields only. But it is possible that brownfield effects could be masked if other types of contaminated properties are also affecting property values.

Traditional hedonic studies include economic variables that are expected to affect property values. Some brownfields are likely to be redeveloped even in the absence of government assistance. Increasingly, the redevelopment of brownfields cannot be justified on purely economic criteria. From a societal perspective, there may be additional benefits that may not show up in property values. Our study looks at economic, environmental (health) and social benefits. It may or may not be possible to discern property value effects of illnesses due to brownfields, or higher crime rates due to these unused or underused properties.

2.2 Data and Model Specification

There is a degree of consensus in hedonic studies to focus on residential property values as the dependent variable, although there have been several industrial property studies. Ideally, sales data are preferable to assessed value, as the latter is less indicative of market values. However, even if sales data are available from such sources as the local Multiple Listing Service (MLS), assessment data can have some advantages. Assessment data are available for all properties, while sales data are only available for the subset of houses that were sold. Assessment data can allow for panel data analysis as many houses will be assessed more than once during a multi-year study. Relatively few houses have repeat sales during a comparable period, and those houses are unlikely to be a random sample. In fact, sales data in general may be biased towards houses in more affluent areas, where sales may be more likely. We collected data for three assessments – 1991, 1997, and 2003—and sales data for 1991 through 2005.

The independent variable of primary interest is distance from the brownfield or brownfield redevelopment. It is likely that most analysts have access to Geographic Information System (GIS) data that allow measurement of distance from brownfields. The working hypotheses in most hedonic studies are that property values will increase at a decreasing rate with distance from a brownfield and that brownfield redevelopment will increase property values of nearby properties, with the increase diminishing with distance. Hence, the specification should allow for the possibility of a non-linear term to capture the diminishing effect on property values of brownfields and their redevelopment.

If there are additional brownfield data, such as site size, type of contamination, and phase of redevelopment, these variables should be included as additional independent variables. These variables may be categorical, such as a value of 1 in the year of a brownfield announcement, and 0 in other years; if the effect is expected to last longer, a value of 1 could be assigned beginning in the year of the announcement and all subsequent years.

Hedonic models of residential single-family housing typically include housing characteristics, of which the most important are house square footage, number of baths and bedrooms, and size of lot. Typically, it is necessary to exclude some house characteristics to avoid multicollinearity.

For example, we included number of bedrooms and baths, but not house square footage.[5] Some studies may include distance to the nearest interstate highway, distance from the central business district, and the like.

If available, it is appropriate to include a representation of income which may have to be aggregated at the block- or Census-tract level, as the income of the individual property owner is unlikely to be available. The inclusion of income helps to hold constant the expectation that higher-income individuals are likely to have more expensive properties. There also may be an endogenous income effect, with brownfields possibly attracting lower income households to an area, and brownfield redevelopment attracting higher income residents, possibly leading to gentrification.

The specification in our study was motivated by the specification in Joel Corona (2004), which looked at brownfields and their redevelopment in Connecticut. Based on studies by Noonan *et al.*(2007a, 2007b), we go beyond Corona insofar as we consider several data samples that differ with regard to maximum distance from the brownfield, and, as just described, the endogeneity issues due to a changing population as a result of varying preferences for living near brownfields or moving near brownfield redevelopment. Noonan refers to direct "price" effects and indirect effects due to changes in neighborhood composition and investment in infrastructure.

While we use several specification variants, a stylized specification is:

$$P = a + b_1D + b_2D^2 + b_3H + b_4N + b_5B$$

where P is house price, from sales or assessment data, D(^{2}) is distance from brownfield (squared) or brownfield redevelopment, H is a vector of house characteristics (square footage or number of baths, bedrooms, lot size, etc.), N is a vector of neighborhood characteristics *(*income, education, race, etc.), and B is a vector of brownfield characteristics (size of brownfield, brownfield density, cleanup announcement, redevelopment, etc.).

Our study used a half-log specification, as do the majority of hedonic studies. In a half-log model, price is converted to logs (typically ln, the natural log base e).

The usual expectation is $b_1 > 0$, $b_2 < 0$, $b_3 > 0$. Expectations for b_4 depend on the variables. Lastly, $b_5 > 0$ for brownfield redevelopment. It might be negative for cleanup announcement, if people were previously unaware of the brownfield. Brownfield size and density of brownfields within a given area could be expected to have a negative effect on property values.

There are measures of non-economic values, such as cancer rates and low birth weights for environment, and crime rates and school dropouts for social considerations. These variables may have an effect on property values, but it may be extremely difficult to separate what portion of the effect should be attributed to brownfields or their redevelopment. We will

[5] Alternatively, the study might use a data reduction techniques such as principal component analysis. In the appendices the paper by Schwarz *et al.* excludes variables while Hao's dissertation employs principal components analysis to deal with multicollinearity.

include a list of variables that could be included in a hedonic model if the social and environmental measures are sufficiently precise. But in our analysis, environmental and social factors had small or insignificant effects when examined separately. We therefore had little confidence that we could find non-economic variables that would be significant in a hedonic model.

2.3 Findings

We found the expected distance effects from brownfields and brownfield redevelopment when our dependent variable was assessed value. But when we used sales values, we got mixed results. Furthermore, results were not always robust with respect to which properties were included in the sample, ranging from all properties within a two-mile radius to a smaller sample of properties within a one-half mile radius.

Hedonic variables had their expected effect, with an increase in bedrooms, bathrooms, or lot size causing an increase in the value of a single family residential home. In some cases in the sales value regressions, the bathroom coefficient had a surprisingly large value on the order of $100,000 for an additional bathroom.

Site redevelopment increases assessment values, with the effect diminishing with distance from the brownfield. The results are weaker for direct effects (when hedonic variables for house and neighborhood characteristics are included) and when sales prices are used rather than assessment value.

Announcement of a cleanup has a positive effect on assessment values, with the effect diminishing with distance from the brownfield. This result does not hold when sales prices are used. If upon cleanup, no contamination is found, property value increases, again with a diminishing effect as distance from the brownfield increases. This result, however, depends on whether the sample includes a 0.5 mile distance or a larger distance from the nearest brownfield. Surprisingly, property value increases with brownfield density. As for the size of the nearest brownfield, results show no clear pattern. Other parts of this report will provide discussion of environmental and social effects.

For a property 0.25 miles from the nearest brownfield, full effects range, depending on the sample of properties included, from $28,000 to $52,000 as the amenity value of not being directly adjacent to the brownfield; direct effects range from $17,000 to $45,000. Development increases value for the same property by $1,038 to $15,843 (the only statistically significant value) for the direct effect and by $5557 to $24,237 for the full effect. Table 2 summarizes the directional findings. Appendix 2 contains the full set of results.

Table 2: Summary of Direct Effects of Brownfields and Brownfield Redevelopment on Property Values

	Sales 1991, 1998, 2003	Sales 1991-2005	Assessment 1991, 1998, 2003
Distance from Nearest Brownfield			
0.5 mile	+	+ **	+ **
1 mile	-	- **	+ **
2 miles	+ **	- **	+
Site Development			
0.5 mile	-	+ **	+ **
1 mile	+ **	-	+
2 miles	+	-	+
Note: ** indicates statistical significance at .01 level.			

2.4 Conclusions

Our study looks at the effect of brownfields and brownfield redevelopment on property values. The detailed analysis, as previously indicated, is in Appendix 2. Our contribution to the knowledge of that issue is three-fold:

1. We compare the results for two different measures of property values: sales prices and assessment values. We get the expected effects for assessment values, for both brownfields (negative, but diminishing effect with distance) and brownfield redevelopment (positive and diminishing with distance), but not for sales values.

2. We obtain results for three different samples: houses within a half-mile radius, a one-mile radius, and a two-mile radius from the nearest brownfield. Results are as expected for all three samples when we use assessment data, but not when we use sales values.

3. We calculate direct effects (including all hedonic variables) and full effects (excluding hedonic variables). The latter allow for endogenous changes in the characteristics of the housing stock due to changes in brownfield status. Full effects, which include both direct and indirect effects, are generally larger.

We recommend that hedonic studies consider these three areas to check the robustness of their results. It is possible to report results selectively, such as for sales prices but not assessed values, a one-mile radius but not larger or smaller, and direct but not full effects. But without a more comprehensive analysis, it will be difficult to tell if the results are robust.

3. The Public Health Impacts of Brownfields and their Reclamation

3.1 Studying the Impacts of Brownfields on Health

The general approach to studying the effects of toxic sites on health is to use the distance from a toxic site as a measure of exposure. A large number of such studies exist in the environmental justice literature (Turner and Wu, 2002), in risk assessment studies (see the EPA Risk Assessment Portal www.epa.gov/risk/guidance.htm, EPA 2001; EPA 2004; Oberg and Bergback 2005), and in epidemiological studies of public health (Schell and Denham 2003). In addition to these studies, Lybarger *et al.* (1998) and Hamilton and Viscusi (1999) have added benefit-cost analyses as a potential tool for studying the effects of toxic sites. Most of these studies are of heavily contaminated sites. The only brownfield studies that have been done are on the City of Baltimore (Litt, Tran, and Burke 2002; Litt and Burke 2002; Ding 2004).

Traditional epidemiological studies use the distance from a toxic site to a population to examine whether populations close to the toxic site have higher negative health outcomes than populations that live further away.[6] Typically health outcome data are gathered at the Census tract or zip code level and distance is calculated to the center of the area. For example, Baibergenova *et al.* (2003) study the effects of proximity to a PCB-Contaminated waste site and low birth weight.

In her brownfield studies, Joan Litt and her colleagues provide one approach to estimating the health impacts of brownfields in Baltimore. Litt examines the health outcomes of heart disease, cancer, stroke, diabetes, pulmonary disease, and liver disease in each Census tract. She then creates an algorithm for the level of contamination at each toxic site and sums across sites and across time to get a measure of the brownfield contamination in the tract. The authors place each tract into one of three categories depending on the degree of contamination of the tract. They then use a log-linear model to estimate the impacts of Census tract contamination on health indicators controlling for socio-economic and demographic variables.[7]

While Litt and her colleagues establish that highly contaminated brownfields can present a health risk to nearby populations, they do not attempt to calculate a dollar value of the risk or estimate the probable benefits of any cleanup activities. The logical next step in integrating

[6] This is an example of Tobler's law which states that everything is related to everything else, but near things are more related than distant things.

[7] The weakness of the Litt *et al.* studies is the development of the algorithm used to estimate contamination levels. Litt, Tran, and Burke (2002) create a chemical specific score by multiplying a suspected negative health outcome from the chemical by five and a known negative health outcome by ten. This score was then multiplied by either 10000 or 1000, depending on the toxicant's chemical persistence. All of these scores were then multiplied by the years of operation at a site and by the site's acreage. Finally, the results were summed across all sites in the Census tract and then the tracts were classified as Low, Medium, or High toxicity. Obviously each step in the algorithm contains a potentially large estimation error and these errors are compounded through the multiplication process.

health effects studies into an approach that examines the total costs of brownfields and the total benefits of redeveloping toxic sites is to place a dollar values on these costs and benefits. Jenkins, Kopits, and Simpson (2006, 15) discuss in their review of studies that have attempted to measure the social benefits how this estimation might be done.

> Applying a direct estimation approach to valuing changes in health outcomes involves four steps: identify toxic pathways where they are found, identify the health risks associated with a toxic/pathway combination, estimate the size of the affected population and their pathway specific exposure, and estimate the willingness to pay for reduced exposure.

Such an approach is extraordinarily complicated. Among the barriers such studies face are: 1) the wide variety of hazardous substances and their combination at a given site requires that each site have a separate estimate, 2) there is a paucity of risk information for many of the substances, and the standard dose-response functions of non-carcinogenic substances are generally not available; and 3) there is little epidemiological information for sites and there is not enough human exposure data available to make accurate estimates of the health effects of most non-carcinogenic chemicals (Jenkins *et al.* 2006).

The combination of these barriers has been so high that in their review of social benefits studies Jenkins *et al.* found only two studies that attempted such analyses. Hamilton and Viscusi (1999) estimate the benefits of cleaning up Superfund sites and Lybarger *et al.* (1998) estimate the health costs of volatile organic compound-contaminated Superfund sites. The substantial data requirements of both studies and the enormous resources required to complete them place such an approach well beyond the resources of most researchers and policy analysts.

A potential problem with any study examining the health effects of brownfields in Charlotte and other cities where the toxic contamination levels are likely to be relatively low is that it is unlikely that epidemiological studies will show *measurable* impacts of sites on health indicators. Most negative health outcomes are relatively rare occurrences, even within a reasonably sized distance from the site such as one-half mile. As we discuss below, this problem is exacerbated when attempting to measure changes in health outcomes in a specific area.

In this study we first follow the traditional epidemiological approach to examine whether brownfields or their cleanup shows measurable impacts on health indicators. We then follow a simplified approach to measuring the health benefits of brownfield redevelopment. We believe this simplified approach can assist local decision-makers in comparing the benefits of redeveloping various brownfield sites.

3.1.1 Data and Model Specifications

Because many of the health impacts from toxic chemicals develop over time through repeated exposure as well as because of long latency periods between exposure and the development of negative health conditions among adults we concentrated our analysis on health indicators that are expected to occur in the short term. Our short-term indicators are low birth weight, infant mortality, and birth defects. The long-term indicator is cancer mortality among persons age 45 and above.

The first step in establishing a relationship between the presence of brownfields and public health problems is a descriptive analysis of socioeconomic information, health outcomes, and exposure from brownfields in Charlotte. We used information at the census block group level and included brownfields that have already obtained or are in the process of obtaining a brownfield agreement with the state.

The commonly used method to determine individuals' exposure to toxic substances is to examine their proximity to hazardous waste sites or industrial facilities. Since specific chemical information is available only after there is a brownfield agreement and an assessment, we were unable to identify the contaminants in the brownfield-like sites that have not entered the agreement.

Using the ArcView GIS program, we created a 0.5 mile buffer for each brownfield site. The selection of 0.5 mile is based on the assumption that brownfields outside this buffer have negligible health impacts. Each block group could contain parts of multiple buffers. The number of buffers that completely or partially overlap a block group is used as one indicator for the proximity to brownfields. Regardless the size of the block group that falls into the 0.5 mile buffer from the brownfield, as long as the block group intersects with the buffer, this block group is assumed to be affected by the brownfield.

Block groups were then ranked using the SPSS Rank Cases procedure based on the number of brownfields in a block group, brownfield density defined by the ratio of brownfield size to block group land area, and the number of buffers a block group contained. We used the SPSS Rank Procedure to categorize brownfield sites into three zones.

- Zone 1 (N=198) where there is no brownfield; brownfield density is zero; and the block does not fall into any brownfield's buffer zone.
- Zone 2 (N=83) where there is no brownfield, but the block falls into the buffer zones of brownfields outside the block.
- Zone 3 (N=48) where the block group contained at least one brownfield. All of the blocks in this set also fall into brownfield buffer zones of brownfields located outside the block.

If a block group is located in Zone 1, people in this block group live at least 0.5 mile away from all brownfields. Therefore, if a block group is located in Zone 2 or Zone 3, people in this block group live closer to brownfields than people in Zone 1.

In the statistical modeling step, health measures, proximity to brownfields, and socioeconomic status were put into OLS models. Because the majority of brownfield projects started after 2000, we used the health measures in year 2000 to estimate the impacts of brownfields on health. The density of inactive hazardous sites in each block group was the ratio of the total square miles of inactive hazardous sites divided by the square miles of that block group. We included this variable to control for potential health impacts from toxic sites not enrolled in the brownfield program. The general form of the model is:

$$Y_i = a + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 H + \beta_5 S + \epsilon$$

where Y_i is the predicted value of health indicator i, Z_2 is the dummy variable for brownfield zone 2, Z_3 is the dummy variable for brownfield zone 3, (and Z_1 His the omitted dummy variable), H is the index of hazardous sites not enrolled in the brownfield program, and S is a vector of socioeconomic and demographic indicators for the census block. Because of multicollinearity among the socioeconomic and demographic variables we used factor analysis to develop a single indicator that combines the percent African American, the percent living in poverty, and the percent of adults with less than a high school education.

3.1.2 Findings for Brownfield Health Impacts

Table 3 shows the findings for the various health indicators prior to the introduction of the socioeconomic/demographic factor. Brownfields appear to have the greatest impact on short-term indicators, particularly low birth weights.

Table 3: Health Trends across Charlotte Brownfield Zones

	Dependent variables				
Independent variables	Low birth weight	Birth defect	Stillbirth	Infant mortality	Cancer mortality
Intercept	5.718**	.693**	.633**	.756**	5.138**
Brownfield zone 3	2.592**	.055	-.014	.072	.176
Brownfield zone 2	2.137**	.032	.428**	.593**	.165
Inactive hazardous site density	.204	.033	-.011	.084	-.126
Adjusted R^2	.084	0	.028	.037	0

Note: ** 0.001 significant level, * 0.05 significant level

When we introduce the control for socioeconomic status and demographic variables, however, the relationship between brownfields and negative health indicators disappears. These results, shown in Table 4, suggest that brownfields do not have a statistically significant impact on any of our health indicators once we control for the socioeconomic and demographic characteristics of the population. We think it is likely that the attributes of low-income and minority populations rather than the brownfields are causal with respect to the health outcomes studied. Persons in vulnerable occupations tend to be exposed to many toxic substances in the workplace. Similarly, low-income adults were more likely to be exposed to high levels of lead as children, and mothers with high levels of lead are more likely to give birth to children of low birth weight and birth defects. Younger mothers, particularly those who have low incomes, are more likely to have low-birth-weight babies than older and higher-income mothers. Finally, low-income and minority populations are more likely to engage in risky behaviors such as smoking that are related to all of our health indicators.

Table 4: Health Trends across Charlotte Brownfield Zones
Controlling for Socioeconomic, Occupational, and Demographic Characteristics

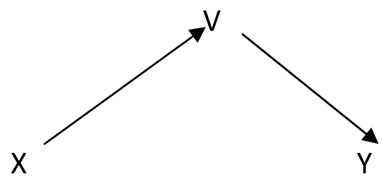
	Low birth weight	Birth defect	Stillbirth	Infant mortality	Cancer mortality
Intercept	5.047**	1.009**	.334	.615*	5.444**
Brownfield zone 3	-.094	-.100	-.425	-.371	-.490
Brownfield zone 2	-.360	-.108	.029	.160	-.492
Inactive hazardous site density	.235	.030	-.008	.084	-.144
SES factor#	1.956**	.214*	.310**	.399**	.856**
Percentage of people unemployed	.109**	-.006	.007	.000	-.056*
Percentage of people in vulnerable occupations†	.034	-.005	.015*	.015	.018
Percentage of house vacancy	.005	-.014	-.001	-.020	-.034
Adjusted R^2	.437	.012	.158	.132	.040

Note: ** 0.001 significant level, * 0.05 significant level

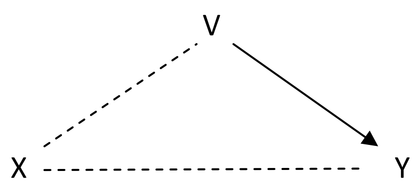
#SES factor is a data reduction that combines the percent African American, the percent living in poverty, and the percent of adults with less than a high school education.

†These occupations include construction, manufacturing, utilities, machine operators and health care.

An alternative explanation would be that the socioeconomic and demographic characteristics are mediating variables between exposure to toxic sites and health outcomes. In other words, brownfields are causal in health outcomes but work through the vulnerable populations indicated by the socioeconomic, demographic, and occupational variables. This explanation would assume the following causal model:



where X denotes the toxic chemicals, V represents the vulnerable population affected by the chemicals, Y is the health outcome, and the solid arrows indicate causal relationships. Unfortunately, in the absence of individual-level data over time, our data cannot distinguish between the above model and the following model. In this model the solid arrow indicates a causal relationship and the dashed lines indicate association without causation.



As we do not have individual-level data over time, we cannot definitively test which explanation is likely to be the more important in explaining negative health outcomes.

3.2 The Impact of Brownfield Remediation on Public Health

To examine whether the cleanup of brownfields had a measurable impact on health indicators at the Census block group level we used a binary logistic regression model. The dependent variable was coded as the difference in health measures in a block group from 2000 to 2006, the period when the brownfields in our study were cleaned up. A block group in which an indicator improved received a score of 1 and block groups where the health indicator remained unchanged or declined received a score of 0. The results showed no statistically significant effect of brownfield cleanup on any health indicator.

This result is unsurprising for three reasons. First, we were dealing with a relatively small number of sites compared to the large number of “brownfield-like” sites that have not signed brownfield agreements. Given that there are at least ten times as many “brownfield-like” sites as there are listed brownfields in Charlotte, it is likely that the health impacts of these other sites overwhelmed any impacts that may have occurred because of the city’s Brownfield Program. Second, the dependent variables in the analysis were the change in the occurrence of relatively rare events such as a cancer or infant death in a block group. Change measures of rare events contain a great deal of stochastic variation. Third, the brownfields that were remediated were only lightly polluted. Only eight of the sites had to have contaminated soil removed. The combination of these factors suggests that this method of estimating the value of brownfield remediation is highly unlikely to provide reliable and valid measures of the impacts of remediation. Because of these limitations in our study, we caution other policy analysts and policymakers of the challenges in using this type of analysis in evaluating brownfield programs.

3.3 Calculating the Potential Benefits from Remediating a Brownfield

The above findings concerning the effects of brownfields and their cleanup suggest that epidemiological research faces challenges if it is to assist policymakers evaluating past or future policy decisions. The 2006 EPA report by Jenkins, Kopits, and Simpson (2006) of benefits that would not normally be included in a benefit-cost analysis includes EPA's critique of Hamilton and Viscusi's work on Superfund's health benefits. That report argues that using epidemiological data to estimate health benefits is likely to greatly underestimate health benefits even of highly contaminated sites. We agree with that conclusion. Does this indicate that including health factors in deciding whether to go forward with a project or in evaluating a project's impacts is not possible? Certainly estimating health impacts for land cleanup programs is exceptionally complicated. Many contaminants, exposure routes, and health endpoints are involved at any given site. In addition, the levels of pollution at every site are different. This makes modeling outcomes highly uncertain. As Jenkins, Kopits, and Simpson (2006) point out, the difficulties are compounded by the paucity of appropriate risk information. For many substances, standard dose response rates and curves are not available and reference dose information (RfD) must be used. Because EPA uses an extremely risk averse approach to set the reference dose,[8] these do not lend themselves to quantifying the health impacts when the RfDs are exceeded. Typically there is not enough human exposure at a given site to produce reliable information about the risks of a particular contaminant. This is likely to be true for most brownfields where the levels of contamination are relatively small.

We believe there are at least two avenues for including health in brownfield policy analyses. Both require the assessment of sites for the presence and concentrations of chemicals on the Agency for Toxic Substances and Disease Registry (ATSDR). The simplest method is to use the ATSDR toxic substance score for a site combined with the site's assessment for carcinogenic substances and their risks. In North Carolina, all brownfield agreements must list the known and suspected hazardous chemicals at the site and the site's total ATSDR score (Wang 2008).

In an ideal world the evaluation of health impacts would follow the work of Lybarger *et al.* (1998). In that study the authors estimated the costs of deaths and illnesses averted.[9] The Lybarger *et al.* paper calculated excess rates of a number of negative health conditions including birth defects, diabetes, and strokes of individuals living within one-half mile of Superfund sites with identified volatile organic compounds (VOC) in the drinking water. These sites had evidence of completed human exposure pathways. The authors calculated the estimates of the economic health burden associated with VOC contamination at Superfund sites in five steps:

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[8] A reference dose is generally 1/10th the dose that is thought to cause problems in the most vulnerable populations such as fetuses. For example, in 2005 the EPA set the RfD for perchlorate at .0007mg/kg/day, a level that was not measurable.

[9] In this particular study the authors estimated the benefits of cleaning up volatile organic compounds (VOCs), but the process would be conceptually similar with any chemical. The Lybarger *et al.* study has been recommended by EPA (see Jenkins *et al.* 2006, and EPA's Science Advisory Board's Advisory Panel on Superfund Benefits Analysis (EPA SAB, 2006) as using techniques that other researchers should follow in establishing the health benefits of toxic site remediation.

a) The estimation of the total population living within one-half mile of Superfund sites that had evidence of completed human exposure pathways for VOCs in drinking water.
b) The calculation of health conditions occurring in excess numbers in populations who were exposed to VOCs in drinking water or who resided near hazardous waste sites and the rate of the excess.
c) The calculation of the expected direct and indirect medical costs and the average costs of lost productivity due to illness or premature mortality.
d) The multiplication of (b) by (c) to obtain the total economic health burden.
e) Appropriately discounting future costs.

Lybarger and his colleagues were able to pull together an extensive set of data from previous health and epidemiological studies that allowed the calculation of costs. For example, for diabetes costs they obtained data from the American Diabetes Association. The costs of birth defects came from a 1994 study in California (Waitzman, Romano, & Scheffler, 1994) and data on the costs of most other medical conditions came from the 1995 Marketscan database. The average per-patient costs were calculated and then adjusted to 1995 dollars.

If researchers had individual-level health data over time they could trace the impacts of cleaning up individual sites and determine the effects of particular chemicals and sets of chemicals on health outcomes. In the absence of such data, some studies have attempted to estimate the costs of deaths and illnesses averted by cleaning up specific chemicals at toxic sites (Hamilton & Viscusi, 1999). One such method is to estimate the value of the "statistical deaths" averted through the cleanup (Viscusi and Aldi, 2002). If there are data on the toxic chemicals at a site and their concentration level, if the total population exposed to the contamination can be calculated, and the value of avoiding the negative health outcome can be estimated, then it is possible to estimate the dollar benefits of cleaning up the site (Lybarger *et al.* 1998). The advantage of this approach is that it includes not only the benefits of averting statistical deaths associated with toxic exposures, but it also estimates the benefits from DALYs, disability adjusted life years. In other words, it looks at the costs of illnesses as well as deaths.

3.2.1 A Simplified Approach

In this study, we simplify the above approaches and estimate only the benefits of averting statistical deaths caused by cancer. We examine the benefits of cleaning up the thirteen brownfields in Charlotte that had entered into a brownfield agreement with DENR and contained toxic chemicals in soil that exceeded the North Carolina cleanup standards. By entering into a brownfield agreement with the state, developers must clean up the site so that toxic chemicals at the site are cleaned up to at least the Preliminary Remediation Goals (PRGs) established by EPA.[10] Chemicals found on sites are assumed to be either cleaned up or properly maintained at the Preliminary Remediation Goals (PRGs) doses when developers comply with the requirements in the Brownfield Agreement. This assumption allows us to estimate the benefits from cleanup created by averting statistical deaths.

[10] http://rais.ornl.gov/prg/prg_document.shtml

According to the EPA document *Users' Guide and Background Technical Document for US EPA Region 9's Preliminary Remediation Goals (PRG) Table*, the calculation of residential PRGs,

> "[U]ses an age-adjusted soil ingestion factor that takes into account the difference in daily soil ingestion rates, body weights, and exposure duration for children from 1 to 6 years old and others from 7 to 31 years old. This health-protective approach is chosen to take into account the higher daily rates of soil ingestion in children as well as the longer duration of exposure this is anticipated for a long-term resident."

Although the majority of brownfields are located in the industrial zones, some of the brownfields were rezoned into mixed use. For this reason, the state of North Carolina has been using the residential PRGs in environmental assessments.

For carcinogens, the US EPA Region 9's Preliminary Remediation Goals (PRG)[11] Table shows that chemical concentrations that correspond to fixed levels of risks in soil, air, and water (i.e. a one-in-one million (10^{-6}) cancer risk). The exposure risk is the chemical concentration (conc) found on site divided by the preliminary remediation goal (PRG) for that particular chemical and then multiplied by 10^{-6}. For multiple pollutants, we sum the risk across all chemicals at the site.

$$\text{Cancer Risk (CR)} = \left[\left(\frac{conc_x}{PRG_x}\right) + \left(\frac{conc_y}{PRG_y}\right) + \left(\frac{conc_z}{PRG_z}\right) + \ldots\right] \times 10^{-6}$$

The reduced cancer risk at each site was then multiplied by the affected population to estimate the cancer incidences that were averted. Based on the five-year relative rate for all cancers combined, the number of cancer deaths averted was estimated.

Estimating the Statistical Deaths Averted

Step 1: Identify toxics

The assessment reports from the brownfields show that there 15 carcinogens found in 13 brownfield sites that exceeded the NC remediation goal at 1.0E-06 cancer risk. Table 5 displays the chemical concentrations collected from Brownfield Agreements and the PRG doses.

Step 2: Identify risks associated with pollutants

The PRG table also indicates the risks associated with pollutants. For example, at ABC Engraves site, Hexavalent Chromium was found in the soil with a concentration of 180mg/kg. The PRG for this chemical is 30 mg/kg, and at this concentration, the chemical is associated with a cancer risk of 6 $\times 10^{-6}$. The rate of chemical concentration to NC standards multiplied by 10^{-6} is the estimated chemical-specific risk for a reasonable maximum exposure. If the site contains multiple pollutants, the sum of chemical-specific risks is the exposure risk for the site.

Step 3: Estimate the size of the affected population

[11] North Carolina is in EPA Region 4, but we could not find an EPA report that related exposure risks and preliminary remediation goals for Region 4.

From each brownfield site we estimated the population living within one-half mile of the site. We assumed that the exposure outside the 0.5 mile would be negligible, therefore, only population within the 0.5 mile radius should be included in estimating the size affected population. The total population that was exposed to brownfields was 8066.

Step 4: Estimate the number of averted cancer incidences

After cleaning up the brownfield, each chemical is assumed to be maintained at the safe dose level. For carcinogens, each chemical-specific risk is 1x 10^{-6}. The cumulative site cancer risk is estimated as the number of chemicals multiplied by 1x 10^{-6}. The original exposure risk minus the after cleanup risk is the estimated reduced risk. The number of averted cancer incidences is then estimated by multiplying the reduced risk with the affected population.

Table 5: Carcinogens cancer risk calculation table

Site	Soil contaminants	Concentration (mg/kg)	NC Standard (mg/kg)	Ratio	Cancer risk	Site cancer risk
ABC Engraves	Hexavalent Chromium	180	30	6.00	6.0E-06	**6.0E-06**
Alpha Mills	Arsenic	42.4	0.39	108.72	1.1E-04	**1.1E-03**
	Chromium VI	474	30	15.80	1.6E-05	
	Tetrachloroethylene	78	0.48	162.50	1.6E-04	
	Trichloroethylene	11	0.053	207.55	2.1E-04	
	1,4-Dichlorobenzene	42	3.4	12.35	1.2E-05	
	Indeno(1,2,3-cd)pyrene	17	0.62	27.42	2.7E-05	
	Dibenz(a,h)anthracene	5	0.062	80.65	8.1E-05	
	Benzo(k)fluoranthene	22	6.2	3.55	3.5E-06	
	Benzo(b)fluoranthene	32	0.62	51.61	5.2E-05	
	Benzo(a)pyrene	23	0.062	370.97	3.7E-04	
	Benzo(a)anthracene	24	0.62	38.71	3.9E-05	
American Cyanamid	Arsenic	17	0.39	43.59	4.4E-05	**4.4E-05**
Camden Square	Trichloroethylene	0.52	0.053	9.81	9.8E-06	**7.6E-05**
	Benzo(a)pyrene	1.6	0.062	25.81	2.6E-05	
	Benzo(b)fluoranthene	1.5	0.62	2.42	2.4E-06	
	Dibenz(a,h)anthracene	1	0.062	16.13	1.6E-05	
	Arsenic	8.47	0.39	21.72	2.2E-05	
Cherokee Oil	Arsenic	234	0.39	600.00	6.0E-04	**6.0E-04**
Dynatech Industries	Arsenic	3.4	0.39	8.72	8.7E-06	**8.7E-06**
Hamilton Property	Arsenic	4	0.39	10.26	1.0E-05	**2.1E-05**
	Methylene Chloride	94	9.1	10.33	1.0E-05	
Home Depot	PCB-1254	4.1	0.22	18.64	1.9E-05	**1.9E-05**
Midtown	Trichloroethylene	0.059	0.053	1.11	1.1E-06	**1.1E-06**
Rea Asphalt Plant	Arsenic	12	0.39	30.77	3.1E-05	**3.1E-05**
Rusak Property	Hexavalent Chromium	1000	30	33.33	3.3E-05	**3.3E-05**
Sonoco Facility	Hexavalent Chromium	47.8	30	1.59	1.6E-06	**1.6E-06**
Terrell Machine	cis-1,3-Dichloropropene	28	0.78	35.90	3.6E-05	**2.2E-03**
	Methylene Chloride	98	9.1	10.77	1.1E-05	
	Tetrachloroethylene	430	0.48	895.83	9.0E-04	

Trichloroethylene	66	0.053	1245.28	1.2E-03

Note: the chemical concentration was from Brownfield Agreements, and the cleanup standard was from NC Inactive Hazardous Sits Branch Health-Based Soil Remediation Goals and EPA Region 9 PRG InterCalc Tables.

Following the above procedures we found that the cleanup of brownfield sites has averted 2.97 expected cancer incidences. Basing our results on the 5-year relative survival rate of 63% for all cancers combined (Battle, L.A. 2004), the cleanup averted 1.1 statistical deaths. According to EPA, the value of a statistical life is $6.9 million in 2008 dollars. Therefore, the brownfield cleanup in Charlotte has generated an economic benefit of $7.59 million in public health improvements.[12] This benefit figure does not include the benefits of averting diseases that do not result in death or that cause long periods of disability preceding death.

3.3.2 Limitations of the Above Approach

Simply using the ATSDR total score at a site or calculating the statistical deaths averted in the manner described above are very rough-and-ready approaches to evaluating the health benefits of brownfield remediation. But the purpose of using either indicator is not to measure the exact total benefits of remediating a brownfield or to generate the benefits part of a benefit-cost analysis of brownfields. The goals are to allow a comparison across projects of the likely health benefits and to include a benefits measure in the brownfield decision process. Simply using the ATSDR total score is by far the easiest approach and allows some measure of comparison across projects. By going the next step and calculating at least some of the potential health benefits, decision-makers can include these benefits in choosing among projects or in justifying a decision to use government incentives to remediate and redevelop brownfields that the market might not choose.

4. Social Benefits of Brownfield Reclamation

Moving beyond traditional economic cost-benefit analyses is a growing trend in the literature and in practice. The EPA has formed a bilateral working group with Germany to develop more well-rounded brownfields programs that consider social aspects of brownfields redevelopments.[13] EPA's Smart-e program explicitly recognizes that "revitalization of potentially contaminated sites should contribute to restoration of natural productivity, native biodiversity, parent soils, water quality, air quality, and social and economic equity. Sustainable revitalization is a holistic approach that considers more efficient use of resources with more profitable economic activity." EPA's P3 program is another example of more balanced approaches to redevelopment. According to the request for applications, "The P3 Awards program is a partnership between the public and private sectors to progress toward sustainability by achieving the mutual goals of economic prosperity, protection of the natural systems of the planet, and providing a higher quality of life for its people."[14]

As Wernstadt, Heberle, Alberini and Meyer (2004) point out,

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[12] As this figure does not include the costs of treating cancers, the work productivity lost to the illness, the value to people of not having cancer to the people who did not die, or the value of any other negative health outcomes averted, it is a very conservative estimate. For a more comprehensive analysis of the costs of diseases caused by toxic sites see Lybarger (*et al.*, 1998).

[13] See the "Smart-e" website for more information: http://www.epa.gov/brownfields/tools/tti_smarte.htm

[14] http://www.epa.gov/P3

> Each brownfield redevelopment decision itself can trigger a variety of concerns related to the long-term vision of a community, threats to public health and nature, economic livelihoods, social equity, and public participation. Addressing these concerns in an integrated fashion at the intersection of social, economic, and environmental forces in principle would exemplify the expansive view of brownfields redevelopment as a palliative to the environmental and social stresses of urban America" (p. 7).[15]

What is missing is a methodology for integrating the social, economic and environmental variables associated with brownfields redevelopment. Unlike the hedonic analysis in this report, there is no generally agreed upon methodology for measuring benefits that cannot be estimated by the willingness-to-pay of the affected population.

4.1 Doing a Study of Non-economic Benefits

Among the barriers to an evaluation of policy interventions that create non-economic benefits are identifying measurable indicators of social benefits, deciding when the policy has been implemented, and determining the appropriate lag time between implementation and when the benefit occurs. At the community level, some cities have produced sustainability reports using data collected at the local level. The purpose of these endeavors is to give policymakers and community members better decision-making tools. Charlotte has had such a project for more than a decade.

4.2 Data and Model Specifications

As indicated in the introductory section of this report, Charlotte has an on-going neighborhood data collection effort includes neighborhood-level indicators of social and environmental conditions. That project, the City-within-a-City (CWAC), collects economic, crime, social, educational, and physical appearance data for neighborhood statistical areas (NSAs) every two years. Each NSA is ranked on 20 variables and, based on these rankings, is labeled as either "Fragile," "Transitioning" or "Stable." Local officials use the data to examine NSA-level trends, to identify areas of instability, and to focus policy interventions.[16] We combined CWAC data with brownfields data to examine the effects of brownfields and their reclamation on neighborhoods.

The CWAC data include summary indicators for the social, crime, physical appearance, and income dimensions of each neighborhood.[17] For example, the summary social indicator includes the percent of persons receiving food stamps, percent of persons over age 64, average kindergarten score, school dropout rate, percent of students passing the state competency exams, percent of births to adolescents, a youth opportunity index, and the number of

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[15] Available at: http://www.rff.org/Documents/RFF-DP-04-46.pdf

[16] The most widespread use of CWAC data is in the real estate sector where buyers and sellers can compare neighborhoods across indicators as well as examining whether a neighborhood is improving or declining.

[17] http://www.athomecharlotte.com/tactical/introduction.htm

neighborhood organizations. As with the overall ranking of a neighborhood, each summary indicator has a value of either "Fragile," "Transitioning" or "Stable."

Our major interest in the analysis of social indicators concerns whether the remediation and redevelopment of brownfields in a neighborhood led to a change in the summary indicators. The general model we use in this analysis is the following:

$$Y_{(2006)} = \alpha + \beta_1 R + \beta_2 Y_{(2000)} + \beta_3 C + \epsilon$$

where $Y_{(2006)}$ is the social indicator score of a neighborhood in 2006; R is the number of brownfields redeveloped in the neighborhood, $Y_{(2000)}$ is the value of the social indicator in 2000, C is the change in the percentage of students passing the statewide competency exam, and ϵ is the error term.

We include the C term in the model because of the change in student assignment policies. As we indicated in the introductory section, the decision by Charlotte Mecklenburg Schools to change its assignment policies may have prevented the redevelopment of neighborhoods with high levels of children in poverty. A typical school in a low-income neighborhood went from having fewer than half of its students eligible for federally subsidized lunches in 2001 to having more than 80 percent of its students eligible in 2002. In some schools, the percent of students eligible for free or reduced lunch was over 95 percent. The major results of this assignment policy change were significant increases in the test-score gap between low-income students and middle-income students and between minority and Anglo students (Godwin *et al.* 2006).

4.3 Findings and Discussion

We began our investigation of social impacts using simple nonparametric correlation analyses. We tested whether the number of brownfields in a NSA was related to any of the summary dimensions and to any of the 20 individual variables. None of the summary indicators was significantly related to the presence of brownfields. Three of the 20 individual variables in the CWAC dataset showed statistically significant relationships with the presence of brownfields. The available infrastructure and the physical appearance of the neighborhood were negatively associated with brownfields while the availability of public transportation was positively related.

Our regression analyses of the various indicators indicated that the redevelopment of brownfields did not lead to a statistically significant change in either the 20 various individual variables or in the four summary measures of the various domains. To allow for maximum variation in the neighborhood quality of life we summed the four summary indicators into a single variable for 2000 and for 2006. We then regressed this variable's value in 2006 on the variable's value in 2000, the number of brownfields cleaned up in a neighborhood, and the change in the percent of students passing the state competency exams. Although the sign of the brownfield cleanup coefficient was in the expected direction, the result was not statistically significant. The change in the student competency scores was significant at $p < .07$, indicating that the decision by Charlotte Mecklenburg Schools to change its assignment policy probably affected negatively low-income neighborhoods.

The paucity of statistically significant impacts of brownfield cleanups was surprising. Bacot and Odell (2005) found that after the redevelopment of brownfields in the South End, the Brookhills neighborhood which borders the South End improved its CWAC overall ranking from its 2000 rating as “fragile” to a rating of “transitioning” in 2002. Bacot and Odell predicted that Wilmore, the other fragile neighborhood that borders the South End, would experience a similar improvement in its rankings by 2004. Bacot and Odell expected that the large investments in the redeveloping brownfields would spur other investment and create hope in the neighborhood. The prediction for Wilmore, however, proved incorrect.

Brookhills and Wilmore have had an enormous amount of brownfield redevelopment. From 2000 to 2006 15 brownfields in Brookhills and 13 brownfields in Wilmore were cleaned up. Each neighborhood has received millions of dollars in private investment and millions more in public infrastructure investments. Both neighborhoods are on the light rail line to the central business district. Despite these investments, Wilmore was unable to improve its overall quality of life measure from 2000 to 2006. On the more positive side, Brookhills did hold onto its “transitioning” status from 2002 to 2006.

4.4 Summary of the Social Impacts

The impacts of brownfield redevelopment have not yet created a statistically significant improvement in the various social indicators available in the CWAC dataset. While the fragile neighborhood with the greatest number of brownfield redevelopment projects did improve, other neighborhoods with substantial redevelopment have not. This lack of measurable improvement is surprising, but it may be the case that improving the overall quality of life in a neighborhood takes substantial time.

5. Policy Implications

Given the absence of consistent, statistically significant relationships between brownfields and their remediation and increases in housing values, improvements in public health, and the enhancement of neighborhood quality of life, the obvious question is whether governments should change their brownfield policies. Before answering that question, it is useful to go back and look at how the agenda for the state and city brownfield programs was set.

5.1 Setting the Agenda: The Development of Charlotte and North Carolina Brownfield Policies

Perhaps the key to understanding the city and state brownfield policies is the recognition of the key role that development interests played in the policy process. Tony Pressley, the developer most responsible for the redevelopment of the South End, initiated Charlotte’s utilization of EPA brownfield assessment grants. Pressley and other developers along with interest groups interested in state economic development and public officials representing Charlotte and Mecklenburg County also were key players in developing the state's brownfield legislation.

5.1.1 Charlotte's Agenda Setting Process

In 1996, Pressley approached the City of Charlotte and encouraged the city to apply for a $200,000 EPA Brownfields Economic Redevelopment Initiative grant for a pilot project in the South End/Wilmore area. As we discussed in the introductory section of this report, public officials in Charlotte did not select the first brownfield policies based on the need to improve fragile neighborhoods. Rather, the developer approached the City with a plan to develop the South End. Market conditions suggested that brownfield redevelopment in this area would be highly profitable. In fact, had the toxic contamination of these properties suggested that there might be a substantial public health problem, the South End probably would not have been chosen.

Charlotte has continued to use the information supplied by the market to determine which brownfields will be developed. The city's Brownfield Program does not solicit new brownfield developments for fragile or transitioning neighborhoods. Rather, developers come to the city with projects the developers have identified. The City then chooses among locations that markets, not social needs, have determined to be most appropriate for investment. Given that the Charlotte Brownfield Program is located within the City's Economic Development Office, it should not surprise us if the projects chosen by developers to maximize profits and to avoid health issues are relatively ineffective in improving health, social, and environmental impacts.

Lawrence Toliver, the Charlotte Chamber of Commerce Vice President for Community Development, talked about how the Charlotte-Mecklenburg Development Corporation (CMDC)[18] picked additional projects after the South End. "Many people on the [Chamber of Commerce] Board of Directors were traditional market based believers. They thought about things in terms of whether they made market sense." To show the Board that they can intervene in the market and make a difference through brownfield redevelopment, Toliver and his staff worked with an independent consultant and the city planning staff to analyze the conditions along 21 business corridors in Charlotte. The CMDC and the consultants "studied which corridor would get the most bang for the buck."

The CMDC study indicated that doing projects on the Wilkinson Boulevard corridor would have the highest visibility and make the biggest economic impact. Once the Board reached the decision to work on that corridor, they hired the consultant again to identify those sites where intervention would make the most sense. The second study came up with eight different sites. After they compared and contrasted the conditions in terms of the market and possible contamination on site, the CMDC took on two projects in that area. One was lightly contaminated from a dry cleaning business, and the site was turned into a Wal-Mart Superstore. The other site was heavily contaminated from various past uses such as a textile

[18] The CMDC is a not-for-profit corporation as a private and public partnership between the City of Charlotte, Mecklenburg County, and the Charlotte Chamber of Commerce

machinery plant, the railroad, a crankshaft company, and a paint company. Eventually the site was turned into the Wilkinson Park Business Center.

The results of all of these projects have been highly positive. The South End has become one of the premier design centers in the Southeast and employs hundreds of workers. The other brownfield redevelopment projects also have increased the tax base and employment rolls. In short, the projects have demonstrated that brownfield redevelopment can be highly profitable and have positive impacts for the city as a whole.

5.1.2 The State's Agenda-Setting Process

Tony Pressley and the South End Development Committee (SEDC) were also instrumental in the drafting and passage of state brownfield legislation (Waterfill and Doyle 1999). The SEDC, the North Carolina Citizens for Business and Industry, a not-for-profit public policy organization, and members of the Charlotte-Mecklenburg city and county governments helped write the 1997 Brownfields Reuse Act (BRA). This legislation encourages brownfield redevelopment by allowing nonresponsible parties[19] to enter into agreements with the North Carolina Department of Environment and Natural Resources. The agreement gives liability protection to non-responsible parties for past environmental contamination on a brownfield site and provides substantial property tax relief for improvements on the properties. The BRA, particularly the tax relief part of the legislation, is a strongly pro-developer policy. It goes well beyond correcting the liability problems created by Superfund legislation.

5.1.2.1 The Public Benefit Requirement of the Brownfield Reuse Act

Section 130a of the BRA requires that a developer supply a public benefit commensurate with the liability protection provided under the law. Developers' interpretation of this requirement provides substantial insight into how public officials have implemented this section of the BRA. We reviewed the 40 Brownfield Agreements that were available at the time of data collection and divided the benefits associated with these projects into four categories: economic development, smart growth, social and environmental, and health and safety (Table 6).

Ninety-five percent of developers thought that their projects would have at least one economic development impact such as creating jobs; increasing local tax base; increasing a property's productivity; helping business retention; adding residential, commercial, and/or industrial space; and spurring additional redevelopment. Sixty-eight percent of the developers listed smart growth strategies such as reducing automobile usage, developing along light rail corridors, and promoting urban infill as public benefits of their projects. In sharp contrast only five developers listed social or environmental benefits and only one developer listed a public health benefit.

[19] A nonresponsible party is one that did not participate in the past pollution of brownfields or the disposal of waste on these sites.

TABLE 6: PUBLIC BENEFITS OF BROWNFIELD REDEVELOPMENT

Developmental benefits	Smart Growth	Social and Environmental benefits	Health and Safety
Create jobs; Increase tax base; Increase property's productivity; Spur additional redevelopment; Add residential, commercial, industrial space; Help business retention	Reduce automobile usage; Develop along light rail; Promote urban infill.	Preserve historical area; Improve neighborhood appearance; Remove blight/stem deterioration; Protect the environment.	Remove contamination; Protect public health; Protect public safety
95%	68%	13%	3%

Note: 95% means that in 95% projects developers mentioned at least one of the benefits in the developmental category.

At first glance, it is surprising that 27 of the city's 40 brownfield applications to DENR listed smart growth as a public benefit while only one application listed public health. However, the North Carolina Department of Energy and Natural Resources believes that every brownfield redevelopment advances Smart Growth. The Executive Summary of DENR's 2002 Brownfields Report to the General Assembly includes the following passage:

> The [Brownfields] Program also supports Smart Growth because every project that reuses property in urban centers reduces suburban sprawl and protects green space. Were it not for the availability of brownfields agreements, many of the redevelopment dollars spent on these projects would otherwise have been spent on projects that contribute to suburban sprawl or promote commercial development in greenspace areas. In a sense a brownfield redeveloped and reused is greenspace saved (p.3)

Another reason that smart growth was a high priority for developers was that in 1998 Charlotte and Mecklenburg County adopted the *2025 Integrated/ Transit Land Use Plan*, and, beginning in January, 2001, DENR mandated that a development's adherence to its smart growth guidelines and recommendations would be an important factor in the Department's considerations of development projects.[20] The cornerstone of the *2025 Plan* was smart growth that emphasized transit oriented development (TOD) and mixed use, high density development (MUDD).

[20] http://www.enr.state.nc.us/docs/denrsmart.pdf

Our interviewees indicated that the Charlotte-Mecklenburg Planning Commission considered the *2025 Plan* to be an important constraint on granting any re-zoning request and would be a key factor in determining the level of infrastructure support the city would be willing to provide. Because of this Plan, smart growth ideology is popular among developers in Charlotte. If a development reflects the smart growth goals of the City's planners, then these count not only toward meeting the public benefits requirement to obtain approval for brownfield projects but also toward gaining the approval of the Planning Commission and for making arguments for infrastructure support.

Ike Heard, the former chair of the Charlotte-Mecklenburg Planning Commission, indicated that the *2025 Plan,* the 1997 North Carolina Brownfields Property Reuse Act, and DENR's orientation were the major factors in the advancement of a smart growth orientation among brownfield developers.[21] The BPRA limited developers' liability for past contamination, and smart growth allowed for higher densities and greater profits. As Heard stated, "TOD requires mixed-use, high density development, and that was the common positive vision for the City and developers." According to Tom Warshauer, the Director of Charlotte's Economic Development Office, the *2025 Plan*, BPRA, and the success of the South End were key factors in the popularity of the reclamation of brownfields in Charlotte. Developers saw brownfield reclamation as highly profitable, planners saw brownfield reclamation as a mechanism to encourage smart growth, and environmental agency officials saw smart growth as a key mechanism to achieve long-term sustainable growth.

In sharp contrast to the number of mentions that economic development and smart growth received in the developers' applications, only thirteen percent identified social and environmental benefits such as preserving historical area, improving neighborhood appearance, removing blight/stem deterioration, and protecting the environment. Perhaps even more indicative of the dominance of economic development as the important public benefits, only one developer listed a health benefit in his application.

5.2 Should the Charlotte and North Carolina Laws be Changed to Reflect Broader Concerns?

A question that has arisen and has been debated extensively by the researchers in this project concerns whether the brownfield programs in Charlotte (and in North Carolina more generally) should weight health and environmental criteria more heavily in the selection of projects. Would the federal funds and state tax abatements have had a greater impact if the governments had subsidized only projects in the lowest income or most highly contaminated areas?

We believe the answer to this question is likely to be negative. As Wang (2008) points out, Charlotte's brownfield projects were placed in areas where health and environmental problems were not higher than could be predicted from the socioeconomic characteristics of the surrounding population. But despite this, the vast majority of the housing surrounding

[21] EPA's website also emphasizes smart growth as an important goal of brownfield reclamation. http://www.epa.gov/dced/about_sg.htm

reclaimed brownfields was occupied by low-income and minority households. Reducing the toxicity of the brownfield sites provided health benefits primarily to disadvantaged households. If the economic success of the South End was a critical factor leading to additional brownfield reclamation then the total health benefits of the South End projects should include the benefits of these additional projects. Had the initial brownfield projects been located in an area that resulted in unsustainable economic endeavors this might have discouraged future brownfield development. Such a project would not have been as efficient despite its immediate direct impact on the health of surrounding communities.

One of the objectives of this study was to integrate social , environmental, health, and economic factors into a single decision matrix. We expected to develop a criterion analysis matrix (CAM) that would allow policymakers to rank different projects on a scale from one to five and to determine if one project dominated all alternatives. Conceptually, the matrix would look as follows:

	Ranking of Benefits*			
	Economic	Health	Environmental	Social
Project 1				
Project 2				
Project 3				
Project 4				

* A higher number indicates greater benefits relative to the other projects.

When benefits can be estimated in dollars, the actual amounts would be used as the information in each cell is designed for comparisons among projects along that dimension. In many situations, however, the time and expense of the data collection would prevent reliable dollar estimates, or the benefit is not suitable for conversion into dollars. In these situations, policymakers would use ordinal rankings. A CAM analysis can assist distributional equity by assigning weighting benefits going to lower income individuals. Alternatively, the decisionmakers could add a social justice column to the matrix.

Building and testing a model based on CAM analysis requires data on environmental and social factors. Based on previous research by Bacot and O'Dell (2006), we expected to use the panel data from Charlotte's longitudinal City-Within-a-City (CWAC) data on neighborhood quality of life. In their research, Bacot and O'Dell had found that the overall quality of life increased in a neighborhood bordering the South End brownfield reclamation project. The CWAC data include 18 different indicators aggregated into summary three-point scales for four dimensions: economic, social, physical, and crime. Dr. Bacot expected to extend his earlier work by examining the association between brownfield reclamation and changes in the quality of life measures. Unfortunately, the CWAC data proved inadequate for this task.
The CWAC data use a scale of 1 to 3 to rank each of the 18 indicators and each of the four dimensions. The data also include an overall quality-of-life score for each neighborhood. Again, the data use a three-point ranking. Such coarse rankings show little variation across time. With such limited variation, it was not possible for us to relate brownfield reclamation to

neighborhood changes. We attempted to recalculate the CWAC data into a more finely grained five-point scale by using all 18 indicators. The only variable that correlated with any change in scores on CWAC's four dimensions was an increased concentration of minority students in a neighborhood's schools. Even this latter association did not reach conventional statistical levels for rejecting the null hypothesis.

The unexpected problems with the CWAC data were compounded by the absence of robust findings for the economic effects and the absence of significant findings for changes in our health indicators. As we discussed above, the size of economic benefits from brownfield reclamation was highly sensitive to model specification. The final difficulty that prevented building a valid CAM model was our inability to find reliable measures of components for the environmental dimension. Dr. Chilton's paper provides the components he included in this effort, but these measures proved to be too "soft" and unreliable for use in a decision model. We are aware that other projects have used decision matrices built on ordinal indicators of economic, social, environmental, and health dimensions. We were unable to build a model that we believed met minimal requirements for reliability.

Our negative results do not indicate that policymakers should not develop a CAM matrix. Doing so aids a more rational decision process and allows decisionmakers to examine how sensitive the rankings of projects is to any given indicator and to the weighting of benefits by equity considerations.

6. Goals not Achieved in the Project

A key goal of the research team when the project started was first to distinguish empirically among those projects where (a) redevelopment would have occurred in the absence of subsidies, (b) successful redevelopment could only have occurred with government subsidies and the social benefits outweighed the social costs, and (c) redevelopment was unsustainable even with subsidies.

Drs. Bacot and Chilton had expected that the CWAC project with its longitudinal data on 18 social, environmental, and economic indicators would provide an opportunity to determine the viability and sustainability of projects. The CWAC data proved to be unsuitable for this task for a number of reasons. First, the CWAC ratings are quite crude. Most neighborhood indicators have only three values: "fragile," "transitioning," and "stable." For this reason, most neighborhood indicators did not change over the six year period of our study. For example, 88% of the neighborhoods ranked "fragile" on their physical appearance in 2000 had the same ranking in 2006. Equally important, there is little consistency in the rankings of neighborhoods across dimensions. The physical appearance ranking of a neighborhood in 2006 was positively rather than negatively related to the amount of crime in the neighborhood and was unrelated to the social ranking of the neighborhood in those years.

As we pointed out in Section 4 above, the rankings and the changes in neighborhood rankings from 2000 to 2006 were unrelated to either the presence of brownfields or their cleanup (Kendall's Tau-b = .09, p=.40). We believe, however, this absence of a relationship is due to the measurement problems in the CWAC data and to the stochastic nature of the change process in those neighborhoods. Our results do not necessarily signify that the reclamation of brownfields did not improve the quality of life in a neighborhood.

A second goal of our project was to develop a methodology that combined economic, social, environmental, and health indicators in a way that would assist policymakers in selecting among environmental projects as well as in evaluating the impact of existing projects on the neighborhood quality of life. We have concluded, however, that our data are insufficient to accomplish this task. The major reason for this insufficiency is the weakness of the CWAC data. Even within the economic analysis where we did not use the CWAC data, the different outcomes in our hedonic models when using assessment versus sales data as well as the absence of robust finding from alternate specifications suggest that it would be imprudent to attempt to include indicators across different domains when we are unable to find consistency within a single domain.

7. Research Dissemination

The research team met on December 15, 2008, with the Office of Economic Development and Brownfield Program staffs. At that time Drs. Schwarz, Godwin, and Wang presented their results and discussed the project's findings. Persons from the Charlotte-Mecklenburg Health Department also attended. On January 8, 2009, the project team made a presentation to the monthly meeting of public administrators in the piedmont region of North Carolina. The goal of this presentation was to increase awareness of efforts to initiate and evaluate brownfield programs.

Peter Schwarz initially sent the paper, "Estimating the Effects of Brownfields and Brownfield Redevelopment on Property Vales," to the *Southern Economics Journal* where it was rejected. He will be revising the paper this summer in preparation for a submission to a different journal, possibly *Land Economics*. He is being assisted in the econometrics by Craig Depken III, who will likely be added as a co-author of that paper.

Drs. Wang and Godwin presented the paper, "Brownfield Policies: Reversing Government Failure," at the North Carolina Political Science Association meetings in March, 2009, and "Intergovernmental Coordination and Brownfield Policies" at the Midwest Political Science Association Meetings in Chicago in April, 2009. These papers address two questions. The first is should governments invest in areas with potentially large health benefits but where market conditions are unlikely to encourage future private development or should the government invest in areas where market conditions are more promising and the brownfield project is likely to spur additional economic development? The second question concerns what are the appropriate roles of the national, state, and local governments in selecting and financing brownfield projects. Based on reviewer comments at the Midwest meetings in Chicago, we are now collecting data on an additional state's brownfield programs and will revise the paper over the summer before submitting it to a journal.

8. Ongoing and Future Research

Although this report ends the EPA-sponsored portion of the brownfields research by the project team, four members of the project team are continuing to work on environmental policy issues and three are extending the work from this project.

Dr. Peter Schwarz is continuing his work on environmental issues by examining market mechanisms that assist in reducing environmental contamination. His paper, Comparing contaminated property redevelopment for mandatory and Voluntary Cleanup Programs in California, is forthcoming in the Journal of Environmental Management. His paper on the Risk-Based Approach to Brownfield Redevelopment will be submitted to a journal this summer.

Drs. Kenneth Godwin and Junfeng Wang are writing two papers on the Charlotte brownfield experience and adding data from the brownfield programs in the metropolitan areas of North Carolina.

1. "Federal, State, and Local Government Cooperation in Solving a Government Failure," will be presented at the environmental panel of the 2009 annual meetings of the Midwest Political Science Association.
2. "Doing Good by Doing Well" examines whether initiating brownfield projects in areas where market forces are strong and levels of contamination are relatively low is more likely to spur future brownfield development than initiating projects in more contaminated and more economically distressed areas.

Dr. Huili Hao currently is extending her work on spatial regression as a tool in evaluating place-based policies that deal with toxic substances.

9. References

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10. Appendices

10.1. Appropriate Variables for an Integrated Evaluation

10.2. Peter Schwarz, 2008. “Estimating the Effects of Brownfields and Brownfield Redevelopment on Property Values,” Paper submitted to the *Southern Economic Journal.*

10.3 Kenneth Chilton, 2007. “The Risk-Based Approach to Brownfield Redevelopment,” paper presented at the 48th annual meeting of the Association of Collegiate Schools of Planning, October 18-21.

10.4 Junfeng Wang, 2008. *The Public Health Impacts of Brownfield Redevelopment in Charlotte, North Carolina.* Doctoral dissertation submitted to the Public Policy Program, University of North Carolina Charlotte.

10.5 Huili Hao, 2008. *The Impacts of Brownfields on Property Values and Private Investment in Charlotte, North Carolina.* Doctoral dissertation submitted to the Public Policy Program, University of North Carolina, Charlotte.

Appendix 1: Variables Appropriate to an Integrated Approach to Evaluating Brownfield Impacts

a) Geographic Variables

i) Distance of a property to the centroid of the brownfield
ii) Square of distance of a property to the centroid of the brownfield
iii) Brownfield density in neighborhood or census block
iv) Total brownfield acreage in neighborhood or census block
v) Distance of a brownfield property to a certain neighborhood / census block
vi) Number of buffers (0.25 mile, 0.5 mile) from the brownfield that pass through each census block
vii) Distance from central business district
viii) Distance from nearest interstate highway

b) Economic Variables

i) Assessed value of the property at multiple time periods (logged), multiple years
ii) Sales data for the property at multiple time periods (logged), multiple years
iii) Median sales price of similar properties (e.g., commercial, industrial, residential)in census block or neighborhood
iv) Control variables for the property (e.g., age, land square footage, heated Square footage, number of bedrooms, number of full baths)
v) Infrastructure variables for census block or neighborhood
vi) Non-brownfield investment in the census block or neighborhood
vii) Median household income
viii) New jobs created
ix) Additional tax revenues

c) Social variables (preferably time series for neighborhood or census block)

i) Property crime rate
ii) Violent crime rate
iii) Percent of adult population without a high school degree
iv) Percent of adult population graduated from college
v) Percent of 8th grade students at grade level in math and English
vi) High school graduation rate
vii) Percent 5 year olds in kindergarten
viii) Ethnic makeup
ix) Percent home ownership
x) Physical appearance index
xi) Substandard housing index
xii) Accessibility to mass transit

- xiii) Unemployment rate
- xiv) Park availability in census block or neighborhood
- xv) Foreclosures
- xvi) Voter turnout
- xvii) Percentage of population who belong to a neighborhood organization
- xviii) Population size within brownfield buffers (o.25 mile, 0.5 mile)

d) Contamination variables by site and by census block (Jun please add)

- i) Brownfield area
- ii) Suspended particulate matter index
- iii) Toxic Release Inventory sites
- iv) Toxic Release Inventory emissions
- v) Other environmental disamenities
- vi) Chemical concentration that above the cleanup standards at each site

e) Health variables by census block

- i) Infant mortality rate
- ii) Low birth weight rate
- iii) Very low birth weight rate
- iv) Cancer mortality rate
- v) Lung disease rate
- vi) Birth defect rate
- vii) Cancer incidences

Appendix 2

Estimating the Effects of Brownfields and Brownfield Redevelopment on Property Values*

*We wish to acknowledge a cooperative agreement with the U.S. Environmental Protection Agency entitled Verifying the Social, Environmental, and Economic Promise of Brownfield Programs, that made this research possible. We also wish to acknowledge useful comments from the other participants in the cooperative agreement: Ken Chilton, Ken Godwin, Huili Hao, and Junfeng Wang. Finally, we are indebted to Doug Noonan for his exceptional comments and suggestions.

Abstract

This paper examines the effects of brownfields and brownfield redevelopment on two measures of property value—sales value and assessment—and finds that property assessment values increase with distance from the brownfield, while sales prices show inconsistent results. Using assessment values, brownfield redevelopment increases nearby property values most. But again, results are inconsistent using sales prices. Results are also sensitive to which properties are included in the sample, ranging from a half mile to a two-mile distance. Finally, full effects that allow for endogenous changes in neighborhood and household characteristics are larger than direct effects, which hold those variables constant.

JEL Classifications

Q51 - Valuation of Environmental Effects

Q24 – Land

Q28 - Government Policy

R52 - Land Use and Other Regulations

1. Introduction

The term `brownfield' means real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.[22] There are estimated to be 450,000 such properties in the United States. The brownfield nomenclature indicates levels of contamination below that of severely contaminated "Superfund" properties, which are subject to joint, several, and retroactive liability as specified in the 1980 CERCLA legislation. Nevertheless, it is suspected that many of these properties were left unused, for fear of possible CERCLA liability.

In 1995, the U.S. Environmental Protection Agency (EPA) initiated a brownfields redevelopment program to counteract the liability perception. While there are a large number of studies citing the benefits of such redevelopment – economic development, preservation of greenfields, etc. – the vast majority of studies purporting benefits are not analytical, and the results are of limited transferability.[23]

This study using data from Charlotte, NC adds to the small number of analytic studies estimating the benefits of brownfield redevelopment. Charlotte is representative of post-industrial cities that are more likely to have lightly contaminated properties than heavily contaminated Superfund sites. The study uses the hedonic technique to examine the effect of brownfields and their redevelopment on property values. The hedonic technique has been widely used to measure the impact of "bads", ranging from air, water, and noise pollution to Superfund sites, leaking underground storage tanks (LUSTs), and locally unwanted local uses (LULUs). The hedonic technique has the advantage that it uses a revealed preference market

[22] The Brownfields Site definition is found in Public Law 107-118 (H.R. 2869) - "Small Business Liability Relief and Brownfields Revitalization Act" signed into law January 11, 2002.
[23] See Jenkins, Kopits, and Simpson (2006).

measure -- property values — rather than stated preference survey methods such as contingent valuation or conjoint analysis that are subject to a variety of well-known biases. The disadvantage is that the hedonic method captures use values, but not non-use values such as ecological value. The current paper restricts the analysis to economic benefits.[24]

2. Selected Literature on the Effects of Contaminated Properties on Property Values

Contaminated properties are likely to reduce property values. As these properties are cleaned up, the negative effect is likely to be offset partially or completely. Finally, redevelopment of these properties is likely to have a positive effect, although the net effect could still be negative, as compared to properties that were free from brownfields in the first place. There is a growing literature pertaining to the effects of contaminated properties, including brownfields, on property values. There are a small number of studies that examine the effect on property values of cleaning up contaminated sites, primarily for Superfund sites. The number is smaller still for studies of redevelopment effects; the few attempts are for brownfields as Superfund sites have not been redeveloped. Wernstedt (2004) has suggested some possible reasons for the lack of brownfield redevelopment studies. The first is that brownfield redevelopment is quite recent, so there is little data on brownfields post-development. Hence, the few studies that portend to provide benefits of redevelopment may be unable to separate the benefits of cleanup from those of reuse. A second possible explanation is that each brownfield has unique circumstances, so that it is not possible to

[24] Property values are not expected to fully reflect non-economic benefits, including social, health, or ecological benefits of brownfield redevelopment.

provide a general method for estimating brownfield redevelopment. In this literature survey, we review literature relevant to estimating economic effects of brownfields, brownfield cleanup, and brownfield redevelopment.

Joel Corona (2004) and other hedonic studies typically model the effect of contamination on property values based on distance from the contaminated or potentially contaminated site. Using Connecticut data for 1990 through 2000 on brownfield locations and housing sales prices,

he finds that property values increase at a decreasing rate with distance from the nearest undeveloped brownfield. After redevelopment, some samples show the distance effect mitigated, although not eliminated. This result suggests that while brownfield redevelopment improves property values, some stigma still remains. However, for some other properties, the distance effect actually increases after redevelopment, a surprising finding. Corona suggests two explanations: heightened awareness strengthening stigma, and increased traffic congestion. He is able to test the second hypothesis, and rejects it, leaving the awareness effect as the remaining possibility.

Leigh and Coffin (2005) note that properties that are small or located in depressed neighborhoods are likely to be overlooked due to public sector emphasis on allocating scarce resources to properties that will realize the greatest market returns. Surrounding properties may be stigmatized. The authors emphasize that their database contains known and potential brownfields. The latter is based on historical land use, including leaking underground storage tanks (LUSTs). The authors also emphasize their use of a threshold modeling strategy to capture neighborhood effects, such as grouping brownfields within 500 to 1000 feet from a property.

The results confirm that brownfields have a negative impact on surrounding property and the neighborhood.

Kaufman and Cloutier (2005) study the Lincoln neighborhood in Kenosha, WI, a neighborhood that was declining but may be turning the corner likely due to a housing program. There were two brownfields and one park in the neighborhood. There were 890 properties, of which about 150 sold in either 1999 or 2000. If the property did not sell, the authors used assessed value. Properties increase by $1341-$4842 on the average if there were no brownfields, and by $2700-$8000 where both properties were redeveloped as parks. Naturally, this result assumes no diminishing returns to additional parks, and that people who live near brownfields are not those who place a minimum value on brownfields.

Kiel (2007) makes the point that it is necessary to observe the relationship between property value and distance from the contaminated site over time to see if the market has completely adjusted to such a site. If the sign remains negative, the sight remains a negative externality; i.e. stigma exists. She estimates the regression for 8 time periods from prior to announcement until development began.[25] Distance is positive and significant for 5 of the 8 regressions. It is not significant in the early stages, consistent with individuals being unaware of pollution. Marginal benefit is largest in the final period. Stigma remains, as prices are lower

[25] Kiel's study touches upon what happens once development begins, something Wernstedt believes studies have generally not distinguished from the cleanup phase. This study not only has cleanup—it has cleanup announcement, cleanup began, final investigation, followed by development of area. As mentioned earlier, Corona also includes brownfield redevelopment.

than prior to announcement. Next, Kiel's study looks at rate of appreciation. Time trend statistics have been insignificant for the last 4 periods, suggesting the market is in equilibrium.

Greenstone and Gallagher (2006) compare sets of properties where contamination did not vary significantly, but some were placed on the Superfund National Priority List (NPL) while others were not. That quasi-natural experiment offers a chance for a counterfactual. Prices of properties placed on the NPL have been found to increase, but their study did not find a significant difference between the rate of price increase between those properties and other contaminated properties that were not placed on the list.

Noonan, Krupka, and Baden (2007) re-examine the Greenstone-Gallagher hypotheses using panel data as well as allowing for endogenous changes in environmental variables and neighborhood. Nevertheless, they too find Superfund cleanup had small and inconsistent effects.

Noonan and Krupka (2007) present an alternative approach for estimating the effect of Superfund properties while allowing for neighborhood dynamics. Simultaneous estimation is appropriate if appropriate instruments can be found to identify each equation. If such instruments cannot be found, effects on property values due directly to Superfund as well as full effects that allow for change in property dynamics can be found by estimating equations with and without housing characteristics and neighborhood variables. Once again, there is a lack of consistent evidence on direct and full effects, as the authors vary their definition of the distance variable, as well as comparing single-equation approaches and the two approaches to endogeneity.

Brid Hanna also allows for endogeneity in a study of polluting manufacturing plants on residential house values and neighborhood incomes. He finds small effects on property values, with a 1.9% reduction in property values one mile from the polluting plant. In addition, he notes that a single equation model misleadingly shows pollution to have a *positive* effect on house values.

Longo and Alberini (2005) note that in order to get total benefits from brownfield redevelopment, we would need to include commercial and industrial redevelopment as well as residential redevelopment. Surprisingly, the authors find commercial and industrial properties are virtually unaffected by proximity to a site with a history of contamination. They find no rebound effect from discovering that a site is no longer contaminated. Furthermore, the size of the site did not matter. In sum, brownfield properties in Baltimore are not particularly attractive investments for developers, and there is little potential for self-sustaining cleanups, such as tax-increment financing (TIFs). It is doubtful that "one size fits all" measures to encourage the cleanup of contaminated sites can be successful in this context.

Ihlanfeldt and Taylor (2004) examine the effect of small-scale hazardous waste sites on commercial and industrial properties in Atlanta, GA. They find a sizable impact on property values, enough to suggest that TIF might prove worthwhile as a cleanup approach.

In sum, most studies of hazardous waste sites such as brownfields that fall short of Superfund levels of contamination tend to show that the presence of a site depresses property values, and site cleanup and redevelopment increases property values. Yet Superfund studies show weaker results, and it is not obvious why less contaminated sites should have a stronger effect on property values than more contaminated sites.

3. Hedonic Model and Data Description

In order to discern the benefits of brownfield redevelopment, we undertake two types of hedonic analysis using data from Charlotte, NC. The first part examines sales values for single family residential houses. The second part uses assessed tax values for single family residential houses for 1991, 1998, and 2003. Ideally, it is preferable to use sales values, as they reflect market transactions, and are available for each year. However, sales values are only available for houses that sold in a given year, leading to possibilities of sample bias. For example, there may be fewer transactions in lower income neighborhoods. Furthermore, there are very few repeat sales, so that it is rarely possible to track what has happened to a given house value over time. By using assessed values, all properties can be included, and it is possible to utilize panel data with up to three observations over time.

The dependent variables are adjusted for house price inflation using an appropriate housing index. Also we provide results where the dependent variable is logged and where it is not. Hedonic studies typically log house price.

Our goal is to estimate the cost of Brownfields, and the benefit of brownfield redevelopment. Along with the usual hedonic housing characteristics, such as square footage, bedrooms, and bathrooms, we include yearly dummies, variables for distance from the nearest brownfield (using GIS) and distance squared, and interactions between the year dummy and each of the distance variables. We include a variety of variables related to brownfields, including the number of brownfields in close proximity to the property, whether or not cleanup has been applied for, whether or not contamination is found, and whether or not there is redevelopment. We would like to have information on whether or not the property has been cleaned up, but currently that information is incomplete. In the case of panel data, we report a fixed effects model, with dummy variables for each brownfield and dummies for the assessment years (2003 is the omitted year).

Table 1 provides summary statistics for the variables included in estimation.

(Table 1 goes here)

Dependent variables are yearfa and indprice, and their log counterparts. Yearfa is assessed dollar value, and indprice is dollar sales price; both variables have been indexed for inflation using a housing price index from the Office of Federal Housing Enterprise Oversight (http://www.ofheo.gov/hpi_city.aspx). Housing sales prices are from Polaris (Property Ownership Land Records Information System), a publically available data set collected by Mecklenburg County, NC. We obtained results for sales of all single family homes using Polaris data for the years 1991 to 2005, for distances of 2 miles, one mile, and one-half mile from the nearest brownfield.[26] Assessed value is provided the Polaris tax database for Mecklenburg County, NC. Assessments took place in 1991, 1998, and 2003. We include dummy variables (y91, y98) for two of the three years in which assessments were done. Housing characteristics came from a GIS database compiled at UNC Charlotte.

Distance from the nearest brownfield, measured in feet, was calculated using the XY coordinates of the centers of the parcels mapped in GIS. To allow for non-linearity, we include distance (dist1) and distance squared (dist2).

We have a number of brownfield-specific variables, including 1) bfdensity, 2) bfshape_area, 3) ann03, 4) bfd_none, 5) bfd_restrict, and 6) site_dev. Brownfield density is the number of brownfields in the same census tract as the property (or 1 if the nearest brownfield is in a different census tract), calculated from GIS data. The second variable indicates the size of the brownfield, measured in square feet. The third variable indicates that by 2003, the government had announced plans to clean up a brownfield. Upon cleanup, it is possible that no brownfield is found (recall that suspected contamination is enough to declare a

[26] All houses in Charlotte fell within a 2-mile radius of the nearest brownfield.

brownfield); the fourth variable equals 1 when no brownfield is found and 0 otherwise. Upon cleanup, restrictions may be placed on what type of redevelopment may take place; the fifth variable equals 1 when the government imposes a restriction. The final brownfield-specific variable indicates whether or not there is evidence of redevelopment taking place on the brownfield. This information was gathered from site visits; a property was considered to be under development if there was evidence of redevelopment in progress or completed.

Housing characteristics include 1) old (and old^2), 2) fullbaths, 3) bedrooms, and 4) shape_area. Old measures the age of the house, calculated by subtracting the year the house was built from the year of the dependent variable. For example, if a house built in 1957 is assessed in 1998, old equals 41. If sales price is the dependent variable and the house is sold in 2004, old equals 47. The data include full, but not half baths, along with the number of bedrooms, and the lot square footage (shape_area).

We begin by discussing the relationship between sales and assessed values, to gauge the reliability of using assessed values in place of sales values. Having both sales and assessment data offers an opportunity to see if results hold for both measures. Given the lack of consistency of the results documented in the literature, it is useful to have more than one measurement of the effect of brownfields on property value, as well as examining the robustness of results for samples with varying maximum distances from the nearest brownfield. After the initial comparison of sales and assessment data, we then examine results using sales data, followed by analysis of panel data using assessment values.

As noted, sales values are available for each year, but only where a house is sold, whereas assessed values are available for only three years, but for all houses. Our initial purpose is to compare results using sales and assessment. We report 2003 only, both because sample size of sold homes is largest, and because brownfield redevelopment is most likely.[27]

(Table 2 goes here)

The two regressions show similar overall goodness of fit. All statistically significant coefficients have the same sign. There is considerable overlap regarding statistically significant coefficients.

As for interpretation, neither equation provides evidence to support the expectation that property value increases (at a diminishing rate) with distance from the nearest brownfield. If upon cleanup, it is found that there is no brownfield, property value increases substantially. Property value also increases with restricting the type of redevelopment, but the effect on property value of site development, while positive, is not statistically significant. Announcement of brownfield cleanup has a large negative effect. This finding can either be viewed as surprising, or as an indication of stigma. It may be that people were unaware of the brownfield until cleanup was announced. In the assessment equation, the announcement effect diminishes at a diminishing rate with distance. Hedonic variables have the expected signs,

[27] We also ran regressions for properties within one-mile and half-mile distances. Sample size dropped considerably, and we do not report those results here. In later results, which make use of the larger assessment sample rather than the sales price sample, we report two-mile, one-mile and half-mile results. We also regressed assessed value (yearfa) on sales price (indprice) for each of the three assessment years to see if sales price was a good predictor of assessed value. Results were similar for the three years. For 2003, sample size was 3586, R^2 was 0.72, the parameter value was 0.77, with a t-value of 96. We expected a coefficient closer to 1, but in examining a scatterplot, a number of properties have assessed values that differ considerably from sales price.

positive for bathrooms, bedrooms, and shape area (a lot size variable). The magnitude of the bathroom variable appears large. The only other significant variable is 'old' (and 'old^2 in the assessment equation), suggesting that value increases with age (at a diminishing rate in the assessment equation). This finding is a mild surprise, as newer houses might be expected to be worth more. It may be that in Charlotte, the highest priced houses are in older neighborhoods.[28]

We will analyze both property sales values and assessed values. However, it is possible that any differences in results could be due to differences in these variables, as coefficient magnitudes show some differences.

4. Analysis of Property Sales and Brownfields

We begin with results for property sales restricted to the assessment years 1991, 1998, and 2003, so as to allow for later comparison with assessment results. We will then turn to property sales using all sales in the years 1991- 2005.

Table 3 results include housing hedonic variables such as number of bathrooms, number of bedrooms, and property square footage (shape area).[29] Noonan and Krupka (2007) refer to these estimates as direct effects, in that by including hedonic variables, housing characteristics and neighborhood conditions are held constant. Table 4 omits the hedonic variables, providing what Noonan and Krupka refer to as full effects. As they explain, a change in the status of

[28] Among Charlotte's most expensive neighborhoods are Myers Park and Dilworth. These neighborhoods were originally streetcar suburbs, built during the 1920s and 1930s. Both neighborhoods are close to center-city Charlotte.

[29] Housing square footage is omitted, given its high correlation with number of bathrooms and bedrooms.

contaminated property – cleanup in their case, announcement of cleanup or site redevelopment in ours—brings about a change in the population in order for property sales to take place. The additional population is directly responsible for changes in housing values that reflect the change in the status of the contaminated property, but may also have indirect effects to the extent that they desire different housing characteristics. For example, if site redevelopment brings about a wealthier population, they may desire larger houses. This indirect effect will further increase the housing sales price. Including the hedonic variables essentially holds variables such as house characteristics constant, so that resulting estimates are direct effects. By dropping these variables from the regression model, these variables are allowed to change. The resulting estimates are full effects, including both direct and indirect effects of a change of status of a contaminated property, as the mix of homeowners changes.[30]

(Table 3 goes here)

(Table 4 goes here)

Sales value increases significantly with distance only when all properties are included.[31]

[30] The population may also shift towards those who place a high value on living near a clean property. Prior to cleanup, those who are less averse to living near contaminated property will be a larger percent of the population. Hence, the increase in property prices may be less than if all homeowners had the same attitude towards contamination.

[31] The lack of statistical significance for the one-half mile sample is likely due to small sample size when only three years of sales are included. We ran the half-log specification, with sales price logged, but do not report these results given the lower goodness of fit of these runs for all three samples. For assessed values, where goodness of fit is higher and there are a greater number of significant coefficients, we include the semi-log model results in an appendix, and draw upon these results along with the non-logged model.

The value increases at a decreasing rate for this sample. The full effect, which includes direct and indirect effects, is larger than the direct effect. Using the table 3 result based on the direct effect for the complete (2-mile radius) sample, a $100,000 house (choosing a value between the mean and median value in table 1) 0.25 miles away from a brownfield is worth nearly $18,000 (1320 ft * 14.74$/ft – 0.0009*1320^2) more than a house directly adjacent to a brownfield. The full effect is almost $27,000 (1320*22.13 -0.00141*1320^2).

Not surprisingly, the hedonic housing variables in table 3 for baths and bedrooms are both positive and significant (although short of statistical significance for the half mile sample). The measure of house lot size (shape_area) is also positive and significant (except not significant for the half-mile sample) The results suggest that older homes have a lower value, with stronger results in table 4 (full effects). Using the results from the two-mile radius sample in table 3, adding 10 years to the age of an otherwise identical home reduces its value by $2781 (-339*10+6.09*10^2).

As for the remaining brownfield variables, the announcement that a site is to be cleaned up is only significant for the one-mile sample. Finding upon cleanup that there is no brownfield has a negative effect, but is significant only for the two-mile sample, while restricting the type of redevelopment is positive and significant for the one-mile and two-mile samples. Both results are opposite of expectations. One possible explanation for the first finding is that prior to cleanup, people were unaware of the brownfield. An announcement upon cleanup that a site is not contaminated could reduce property values if there is a stigma attached to a property that now is known was suspected of contamination, even though none was found. A possible explanation for the second finding is that there can be a positive externality to properties if zoning restrictions on redevelopment prevent negative externalities that can depress property values; e.g. residential redevelopment is more valuable if industrial uses are not permitted nearby.

The benefit to property value from brownfield redevelopment (site_dev) is positive and significant for the one-mile sample only, though it is also positive for the two-mile sample. Both samples show the benefit to redevelopment decreases, at a decreasing rate, with both coefficients significant, with distance from the brownfield. These results are consistent with expectations that site development increases property values, but less so with greater distance from the redevelopment. Using the table 3 one-mile sample, a house located 0.25 miles from the brownfield increases in value \$36,258 ($139{,}831-92.9182*1320+0.01095*1320^2$) due to site development.

An increase in brownfield density decreases property values for the two-mile sample, the only case where the coefficient is significant. Property value decreases with an increase in the size of the nearest brownfield. Both results agree with expectations.

We now turn to results using all sales for the years 1991-2005. The larger sample size should provide more statistically significant results. For brevity, we report direct effects only.

(Table 5 goes here)

In table 5, distance effects are no longer consistently positive, contrary to expectations. Using sales for all years, results are as expected—increasing (at a decreasing rate) -- for the half-mile sample, but opposite of expectations for the two larger samples.

Hedonic variables show the expected signs, but magnitude of the fullbath variable for the one-mile and two-mile radius samples seems unreasonably large. House value increases with age, whereas results for the smaller sample, when significant, showed the expected decrease.

An announcement that the site will be cleaned up now results in a drop in value (the three year results, where significant, showed the expected increase in value). This result is surprising, unless stigma is the dominant factor.

If cleanup shows no contamination, property value increases, as would be expected, in contrast to the three year sales value results. Restricting the type of brownfield redevelopment reduces property values in the two significant cases, again the expected finding, and again opposite of the earlier finding. Brownfield site development increases property value significantly for the half-mile sample only; the earlier result was positive and significant for the one-mile sample only. Brownfield density coefficients are significant, but with inconsistent signs. Finally, an increase in the size of the nearest brownfield reduces property values (as was also found with the three year sample).

Overall, the lack of consistency in results for the different samples makes generalization difficult. Results for samples at different distances from the nearest brownfield, and for three years of sales price data vs. all years, do not show clear patterns.

5. Analysis of Assessment Values and Brownfields

We turn now to assessment results. While these values have the disadvantage that they are not true market values and are only available for three years, they have the advantage that the observations are for the same properties, forming a panel of up to 3 observations. Tables 6 and 7 contain panel data results, with hedonic variables included (direct effects) and excluded (full effects). We include all available assessed values for 1991, 1998, and 2003.[32]

(Table 6 goes here)

(Table 7 goes here)

Tables 6 and 7 contain direct and full effects of brownfields based on assessed values adjusted using a house price index (yearfa), where the dependent variable has not been logged. The advantage of this specification is that the estimated coefficients can be easily interpreted in dollar ($) terms. Other common specifications are semi-log and log-log. We report semi-log results, where the dependent variable has been logged, in an appendix, and draw upon these results to the extent that they reinforce or conflict with the linear specification. Results vary somewhat depending on whether we include all properties in the sample, which fall within a two-mile radius, or a one-mile or half-mile radius. While goodness of fit for the linear and semi-log specifications is comparable for the two-mile radius, goodness of fit is somewhat higher for

[32] Houses built between 1992 and 1998 have only two assessed values, while houses built after 1998 have only one assessed value, resulting in an unbalanced sample. We also ran results for the balanced samples. The first was for all houses assessed in 1991, allowing three observations for each house. The second was for all houses assessed in 1998 but not in 1991, providing two observations per house. We do not report these results, given that they do not use the information as fully as the unbalanced sample. We also tried a first-differences model, but given that we have between one and three observations per house, that model sacrifices too much data, including all houses assessed for the first time in 2003.

the linear specifications for the one-mile and half-miles samples.[33] The appendix contains tables A1 (direct effects) and A2 (full effects) for the semi-log specification.

Goodness of fit is similar for all three linear samples, while goodness of fit increases with allowing for properties a greater distance from the nearest brownfield for the semi-log specification. All results show property values increasing with distance from the brownfield, with statistical significance in all cases but the direct effect for the linear two-mile radius. $Distance^2$ has the expected sign, showing a diminishing effect, in the cases where it is statistically significant. There is inconsistency in the effect of age of the house on price, with statistically significant increases and decreases. All three hedonic variables—shape_area, fullbaths, bedrooms—have the expected sign and are significant. Linear results show a bathroom adding more to value than a bedroom, while two of the three semi-log results show a bedroom adds more.[34]

All show a boost to property values when cleanup reveals that there is no brownfield, with statistically significant coefficients for all three linear results, but only one of three semi-log coefficients. This result is consistent with the result found using 15 years of property sales, and in contrast to the finding using property values for the three assessment years, where finding no brownfield surprisingly resulted in lower property values. Restrictions placed on how

[33] Cropper, Deck, and McConnell (1988) and Halstead, Bouvier, and Hansen (1997) suggest an alternative to goodness of fit in choosing functional form, based on the Box-Cox Transformation. Cropper, Deck and McConnell showed how different specifications might over- or under-estimate the true magnitude, hence the desirability of choosing the correct specification. But with the number of possible functional forms, the number of independent variables, and the choice of which properties to include based on distance from the nearest brownfield, ranking the functional forms would be unwieldy.

[34] Half baths are not included in this measure. So the value of a bathroom is biased upwards.

the brownfield can be redeveloped reduce property value based on the half- and one-mile results, but positive (and significant for the semi-log) for two miles. Restrictions leading to a decrease in assessed value are consistent with the result obtained using 15 years of sales data. The surprising positive finding that restrictions increase assessed value, found here for the two-mile radius, was also found using the sales prices for the three assessment years. So results for this variable are not conclusive. Announcement of a cleanup has a positive and sometimes significant effect for both linear and semi-log, with the effect diminishing significantly with distance from the brownfield, in contrast to the surprising finding when 1991-2005 sales values were regressed.

Brownfield redevelopment has a positive and significant effect only for the half-mile sample, although the effect is positive and not far from significance for the one-mile sample. Within the one-half mile radius, the positive effect of redevelopment decreases, at a diminishing rate, with distance from the redevelopment. The semi-log results are positive and significant, and diminish with distance, for both the half-mile and mile results. The two-mile result shows the opposite set of results. Brownfield density has significant coefficients, but inconsistent signs; the log results are consistently positive—a surprising sign—and significant. Finally, the size of the nearest brownfield (bfshape_area) does not have a consistent sign. For both the linear and semi-log models, the effect is positive and significant for the two-mile radius, negative and significant for the half-mile, and insignificant for the one-mile sample.

Table 7 shows full distance effects are considerably larger than direct distance effects. For a property 0.25 miles from a brownfield, assessed value increases by between $17,000 (1320*13.19 for one-mile sample) and $45,000 (1320*34.44 for one-half mile sample) based on direct effects. The full effects for these two distances are between $28,000 (1320*21.62) and

\$52,000 ($1320*50.67-0.008*1320^2$). Property values at a greater distance from a brownfield increase by a larger amount when allowing for change in neighborhood composition and house characteristics than when these hedonic variables are included in the equation, consistent with the sales price results. The full site development has a larger effect, and is now significant in all samples. Whereas brownfield redevelopment had a positive and significant direct effect for the half-mile sample only, the full effect is positive and significant for all three samples. Brownfield economic development has a convincing positive effect if we allow for its indirect effects on neighborhood composition. Based on direct effects alone, the case is less convincing.

We summarize sales and assessment results for the two main brownfield variables of interest: distance from the brownfield, indicating the cost of brownfields, and brownfield redevelopment, indicating the benefit of cleaning any contamination and redeveloping the property.

(Table 8 here)

Assessment results show the expected positive effects in all cases, with property values increasing with distance from the brownfield and with site development, although the signs are not always significant. Results using sales show no consistent pattern for either distance or site development. Using sales for the three assessment years, there are positive signs for two of three samples for each of the two variables, and only one of three samples is positive and statistically significant for each variable. Using sales for 1991-2005, the reverse results hold, with two of three signs negative for each of the two variables, with the results significant for distance only. There are also two positive signs, one for each variable, and both are statistically significant, showing the lack of consistency for the sales price results, particularly for the 1991-2005 sample.

6. Conclusions

Some, but not all, hedonic studies have concluded that property values increase at a decreasing rate with distance from a brownfield. Our results show that findings for this variable, and other variables related to brownfields and brownfield reuse, are sensitive to the sample of properties included and the measure of property value. In addition, in measuring the effects of brownfields and brownfield redevelopment, there are both direct and full (direct and indirect) effects.

We have examined the effects of brownfields and brownfield redevelopment using property values and assessment. In comparing results from property sales for 1991-2005 and assessment for 1991, 1998, and 2003, for samples of properties one-half, one-mile, and two miles from the nearest brownfield, we have large enough sample sizes to have a number of statistically significant results. Those results do indeed show property value to increase, at a diminishing rate, with distance from a brownfield.

Site development increases property values, with the full effect diminishing with distance, at a diminishing rate, based on assessment values. If site development effects as measured by assessment values are limited to direct effects, the results are less convincing. The results are also less convincing based on sales values.

The evidence using assessment values suggests that announcement of a cleanup has a positive effect on value, diminishing at a diminishing rate with distance from the brownfield, while the results using fifteen years of property sales suggest a surprising negative effect, and are insignificant using sales data from the three assessment years . If upon cleanup, no contamination is found, property value increases, with the effect diminishing with distance. But these results are sensitive to on the sample used with respect to distance from the nearest brownfield. Surprisingly, brownfield density tends to be associated with an increase in property values. There is no clear pattern to the variable measuring the size of the nearest brownfield.

We conclude with the following three take-away points. Using assessment values, property value increases at a decreasing rate with distance from the nearest brownfield. Again for assessment data, brownfield redevelopment increases property values, with the effect diminishing with distance from the brownfield. Lastly, however, results are sensitive to such factors as the what properties are included with respect to distance from the brownfield, the measure of property value, such as sales price or assessment, and whether the effects of brownfields and brownfield redevelopment are limited to direct effects, or encompass full effects, allowing for changes in house characteristics and neighborhood composition.

Appendices

Appendix 1

Half-Log Model: Regression Estimates (Direct and Full Effects) for Assessed Values

(Table A1 goes here)

(Table A2 goes here)

Appendix 2

Description of Data Sources

Dependent variables are yearfa and indprice, and their log counterparts. Yearfa is assessed dollar value, and indprice is dollar sales price; both variables have been indexed for inflation using a housing price index from the Office of Federal Housing Enterprise Oversight (http://www.ofheo.gov/hpi_city.aspx). Housing sales prices are from Polaris (Property Ownership Land Records Information System), a publically available data set collected by Mecklenburg County, NC. We obtained results for sales of all single family homes using Polaris data for the years 1991 to 2005, for distances of 2 miles, one mile, and one-half mile from the nearest brownfield.[35] Assessed value is provided the Polaris tax database for Mecklenburg county, NC.

Housing characteristics came from a GIS database compiled at UNC Charlotte. Housing characteristics include 1) old (and old^2), 2) fullbaths, 3) bedrooms, and 4) shape_area. Old measures the age of the house, calculated by subtracting the year the house was built from the year of the dependent variable. The data include full, but not half baths, along with the number of bedrooms, and the lot size square footage (shape_area).

We have a number of brownfield-specific variables, provided by Ms. Emily Burns, Economic Development Division for the City of Charlotte, including 1)bfdensity, 2)bfshape_area, 3)ann03, 4)bfd_none, 5)bfd_restrict, and 6)site_dev. Brownfield density is the number of brownfields in the same census tract as the property (or 1 if the nearest brownfield is in a different census tract), calculated from GIS data. The second variable indicates the size of

[35] All houses in Charlotte fell within a 2-mile radius of the nearest brownfield.

the brownfield, measured in square feet. The third variable indicates that by 2003, the government had announced plans to clean up a brownfield. Upon cleanup, it is possible that no brownfield is found (recall that suspected contamination is enough to declare a brownfield); the fourth variable equals 1 when no brownfield is found and 0 otherwise. Upon cleanup, restrictions may be placed on what type of redevelopment may take place; the fifth variable equals 1 when the government imposes a restriction. The final brownfield-specific variable indicates whether or not there is evidence of redevelopment taking place on the brownfield. This information was gathered from site visits; a property was considered to be under development if there was evidence of redevelopment in progress or completed. Distance from the nearest brownfield, measured in feet, was calculated using the XY coordinates of the centers of the parcels mapped in GIS.

The data and programs are stored on an external hard drive. The essential data and programs can be extracted onto a CD for purposes of duplication by other researchers.

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Table 1: Summary Statistics for All Properties in Sample

Variable	Mean	Median	Minimum	Maximum	Std Dev
yearfa	98655.91	73206.33	0	3791396.79	97989.52
indprice	119852.64	90599.41	270.7275804	9961279.04	128140.91
lnyearfa	11.2441681	11.2011893	4.9631906	15.1482451	0.6746382
lnindprice	11.4047783	11.4142029	5.6011131	16.114216	0.7746162
y91	0.2946025	0	0	1	0.4558652
y98	0.3337607	0	0	1	0.4715567
dist1	7733.88	8291.75	123.227432	10559.95	2300.46
dist2	65105043.88	68753162	15185	111512453	31341762
y91_dist1	2280.2	0	0	10559.95	3743.3
y91_dist2	19211536.22	0	0	111512453	34260461.73
y98_dist1	2589.15	0	0	10559.95	3889.11
y98_dist2	21828749.22	0	0	111512453	35712860.05
bfdensity	1.119165	1	1	12	0.7274466
bfdensity_91	0.3322234	0	0	12	0.6497251
bfdensity_98	0.3732138	0	0	12	0.6712081
old	36.6743739	38	0	210	20.8626115
old2	1780.26	1444	0	44100	1712.86
ann03	0.6673171	1	0	1	0.4711754
ann03_dist1	5065.32	6065.48	0	10559.85	4076.55
ann03_dist2	42275698.73	36790036	0	111510370	39856259.9
fullbaths	1.5489406	1	0	9	0.6721265
bedrooms	2.9786085	3	0	25	0.713354
Shape_Area	17436.57	12045	45.605	9205660.2	67451.55
site_dev	0.1184332	0	0	1	0.3231213
dev_dist1	948.7542951	0	0	10559.85	2707.48
dev_dist2	8230523.79	0	0	111510370	24968112.48
bfd_none	0.0607993	0	0	1	0.2389624
bfd_restrict	0.1837139	0	0	1	0.3872518
bfshape_area	778129.14	155694.87	5123.21	5173000.81	1541009

Table 2: Comparison of Sales Price (indprice) and Assessment Value (yearfa) Regressions 2003

Two-mile radius				
	Dependent Variable: indprice	Pr > |t|*	Dependent Variable: yearfa	Pr > |t|
R-Squared	0.439		0.4399	
Sample Size	3587		3587	
Intercept	-206727	**<.0001**	-182222	**<.0001**
dist1	4.598	.5522	-11.487	0.1005
dist2	-0.0003	0.5498	0.001	0.0512
old	1529.56	**<.0001**	3304.9	**<.0001**
old2	0.2603	0.9012	-16.38	**<.0001**
announce03	-50713	0.063	-84694	**0.0006**
ann03_dist1	11.35	.1720	22.3	**0.003**
ann03_dist2	-0.0005	0.4141	-0.0014	**0.0102**
FullBaths	106593	**<.0001**	84265	**<.0001**
bedrooms	22100	**<.0001**	24919	**<.0001**
shape_area	1.104	**<.0001**	0.853	**<.0001**
Site Dev	36948	0.1489	13677	.5544
dev_dist1	-15.645	**0.05**	-6.48	0.3689
dev_dist2	0.001	0.0515	0.0005	0.3925
bfd_none	36653	**<.0001**	37356	**<.0001**
bfd_restrict	13934	**0.0036**	10953	**0.0114**
Notes: Old = Current Year-Year Built. Bolded p-values indicate statistical significance at 0.05 or better.				

Table 3: Direct Effects (Hedonics Included) of Brownfields and Brownfield Redevelopment on Housing Sales Prices (indprice)

1991, 1998, 2003

	One-half mile			One mile			Two miles		
	Parameter estimate	Sig.	t value	Parameter estimate	Sig.	t value	Parameter estimate	Sig.	t value
intercept	-106577		-0.98	69302	**	2.55	-39126	**	-2.26
y91	104638		0.58	-33456		-0.86	4880.379		0.17
y98	-4416.7		-0.05	46031		1.52	11489		0.61
dist1	108.55		0.81	-30.3518		-1.66	14.73869	**	2.56
dist2	-0.023		-0.59	0.00808	**	2.72	-0.0009		-2
y91_dist1	-196.792		-0.63	43.45202		1.36	-13.2702		-1.4
y91_dist2	0.07866		0.61	-0.00948		-1.76	0.000946		1.24
y98_dist1	48.07417		0.48	-7.83217		-0.41	-9.48622		-1.58
y98_dist2	-0.02297		-0.78	-0.00145		-0.49	0.000555		1.19
old	519.247		1.34	-285.561		-1.67	-339.411	**	-2.41
old^2	-3.31039		-1.49	2.0974		1.56	6.09163	**	4.09
shape_area	0.09151		0.23	0.31874	**	2.00	0.9909	**	13.13
fullbaths	31323	**	2.78	12081	**	2.86	30683	**	9.68
bedrooms	14747		1.75	13304	**	4.43	20370	**	9.59
bfd_none	-30375		-1.31	-13539		-1.81	-38305	**	-8.4
bfd_restrict	-4098.73		-0.24	31581	**	4.62	27982	**	6.15
ann03	87031		0.82	-35472		-1.24	-11624		-0.71
ann03_dist1	-118.842		-0.95	13.38631		0.71	-4.98306		-0.85
ann03_dist2	0.02746		0.76	-0.00348		-1.17	0.000797		1.7
site_dev	-106777		-0.7	139831	**	3.68	20882		0.98
dev_dist1	181.296		1.02	-92.9182	**	-3.41	-18.2427	**	-2.14
dev_dist2	-0.06188		-1.24	0.01095	**	2.46	0.00154	**	2.11
bfdensity	13959		1.21	994.7597		0.4	-4552.69	**	-4.13
bfshape_area	-0.03952		-1.72	-0.01184	**	-4.56	-0.00405	**	-2.74
	R2=0.39	N=117		R2=0.52	N=465		R2=0.49	N=1700	

Brownfield fixed effects included in regression, but not reported. ** sig. ≥ 95%

Table 4: Full Effects (Hedonics Omitted) of Brownfields and Brownfield Redevelopment on Housing Sales Prices (indprice) 1991, 1998, 2003

	One-half mile			One mile			Two miles		
	Parameter estimate	Sig.	t value	Parameter estimate	Sig.	t value	Parameter estimate	Sig.	t value
intercept	-31483		-0.28	126296	**	4.54	79953	**	4.26
y91	299269		1.6	-19394		-0.47	-9901.28		-0.3
y98	46694		0.53	78658	**	2.47	9598.994		0.44
dist1	156.5508		1.1	-22.6997		-1.17	22.13065	**	3.32
dist2	-0.03748		-0.9	0.00757	**	2.4	-0.00141	**	-2.71
y91_dist1	-572.03		-1.81	31.91381		0.94	-12.3647		-1.13
y91_dist2	0.24086		1.84	-0.00784		-1.37	0.00105		1.18
y98_dist1	-17.5053		-0.17	-25.2694		-1.25	-5.74238		-0.82
y98_dist2	-0.003		-0.1	0.00094		0.3	0.000264		0.49
old	-37.0164		-0.1	-412.277	**	-2.53	-878.554	**	-5.81
old^2	-1.67615		-0.75	2.18384		1.58	8.97269	**	5.32
bfd_none	-19202		-0.87	-9033.63		-1.16	-31479	**	-6.01
bfd_restrict	1688.788		0.09	35854	**	5	51406	**	10.04
ann03	113576		1.01	-37423		-1.23	8821.577		0.47
ann03_dist1	-148.973		-1.11	17.65335		0.88	-15.9591	**	-2.36
ann03_dist2	0.03562		0.93	-0.00496		-1.58	0.00165	**	3.06
site_dev	-67766		-0.42	159217	**	3.94	22682		0.92
dev_dist1	135.9246		0.72	-103.784	**	-3.59	-19.6706	**	-1.99
dev_dist2	-0.04822		-0.91	0.01208	**	2.55	0.00179	**	2.11
bfdensity	10963		1.05	-1081.59		-0.42	-5954.42	**	-4.68
bfshape_area	-0.04235		-1.79	-0.01545	**	-5.75	-0.00468	**	-2.76
	R^2=0.27	N=117		R^2=0.45	N=465		R^2=0.29	N=1700	
** sig. ≥ 95%									

Table 5: Direct Effects of Brownfields and Brownfield Redevelopment on Housing Sales Prices (indprice)

1991-2005

	One-half mile			One mile			Two miles		
	Parameter estimate	Sig.	t value	Parameter estimate	Sig.	t value	Parameter estimate	Sig.	t value
intercept	-68,020	**	-3.08	-182,782	**	-11.13	-214,356	**	-30.56
dist1	50.30	**	1.97	-25.16	**	-2.85	-11.20	**	-6.27
dist2	-0.017	**	-2.39	0.005	**	3.45	0.0008	**	6.10
old	126.06		1.35	1983	**	17.83	1686.43	**	30.99
old^2	0.03		0.04	-9.16	**	-7.41	-4.79	**	-7.18
shape_area	0.169	**	4.12	0.20	**	6.29	0.397	**	49.13
fullbaths	36,220	**	17.33	101,237	**	53.79	105,348	**	135.32
bedrooms	18,261	**	12.19	31,360	**	21	37,589	**	55.59
bfd_none	-867.28		-0.19	7790.63	**	2.53	11,941	**	8.12
bfd_restrict	1721.32		0.55	-14,320	**	-5.02	-15,312	**	-12.73
ann03	-8601.27		-0.37	-36,518	**	-2.28	-69,148	**	-10.21
ann03_dist1	-29.04		-1.06	17.58		1.75	25.05	**	12.11
ann03_dist2	0.013		1.67	-0.002	**	-1.50	-0.112	**	-10.14
site_dev	51,299	**	2.29	-3245.64		-0.15	-17,644		-1.86
dev_dist1	-29.72		-1.10	-5.59		-0.39	1.59		0.53
dev_dist2	0.0026		0.33	0.0004		0.17	-0.0001		-0.53
bfdensity	6368.93	**	5.83	-7127.20	**	-7.79	-2597.74	**	-4.59
bfshape_area	-0.02	**	-5.71	-0.004	**	-3.02	-0.003	**	-8.20
	R2=0.34	N=2439		R2=0.39	N=10,964		R2=0.44	N=65,723	
Year dummies included in regression, but not reported. ** sig. ≥ 95%									

Table 6: Direct Effects (Hedonics Included) of Brownfields and Brownfield Redevelopment on Assessed Value (yearfa) 1991, 1998, 2003

	One-half mile			One mile			Two miles		
	Parameter estimate	Sig.	t value	Parameter estimate	Sig.	t value	Parameter estimate	Sig.	t value
intercept	86,743	**	4.67	-92,504	**	47.43	-80,727	**	21.49
y91	-3652		-0.46	6970		1.1	18,162	**	5.25
y98	2490		0.32	3776		0.61	7526.59	**	2.24
dist1	34.44	**	3.05	13.19	**	3.19	1.61		1.61
dist2	-0.006		-1.74	-0.0005		0.77	0.0001		1.6
y91_dist1	12.79		1.32	1.09		0.27	-5.24	**	-5.04
y91_dist2	-0.005		-1.76	-0.0007		-1.17	0.0002	**	2.8
y98_dist1	3.64		0.38	1.27		0.32	-2.26	**	-2.24
y98_dist2	-0.002		-0.79	-0.00006		-0.97	0.00005		0.87
old	-411.67	**	-8.77	153.44	**	2.87	-199.3	**	-6.65
old^2	0.49		1.07	-2.3	**	-4.16	1.2	**	3.66
shape_area	0.29	**	35.22	0.3835	**	54.15	0.34	**	96.49
fullbaths	17,121	**	20.94	37,159	**	48	47,115	**	124.89
bedrooms	12,584	**	21.25	21,627	**	36.5	20,458	**	65.88
bfd_none	9635	**	4.20	29,606	**	16.69	16,809	**	2.3
bfd_restrict	-91,036	**	-8.60	-16,014		-1.75	57,662		1.55
ann03	16,527		1.52	60,685	**	8.05	3063.92		0.08
ann03_dist1	-24.71	**	-2.29	-27.95	**	-7.04	6.78	**	7.3
ann03_dist2	0.005		1.61	0.0034	**	5.64	-0.0007	**	-9.76
site_dev	60,050	**	5.46	18,595		1.92	3989.31		0.83
dev_dist1	-44.05	**	-3.36	-7.26		-1.14	-2.5		-1.64
dev_dist2	0.008	**	2.02	0.0006		0.65	0.0002		1.61
bfdensity	2688	**	4.06	1276	**	2.17	-547.32		-1.37
bfshape_area	-0.126	**	-8.82	-0.004		-0.43	0.013	**	9.32
	R2=0.62	N=6033		R2=0.63	N=24,411		R2=0.64	N=134,047	
Brownfield fixed effects – separate dummy variables for each brownfield-- included in regression, but not reported. ** sig. ≥ 95%									

Table 7: Full Effects (Hedonics Omitted) of Brownfields and Brownfield Redevelopment on Assessed Value (yearfa) 1991, 1998, 2003

	One-half mile			One mile			Two miles		
	Parameter Estimate	Sig.	t value	Parameter Estimate	Sig.	t value	Parameter Estimate	Sig.	t value
intercept	147,025	**	6.63	-11,264		-0.71	20,130	**	4.72
y91	-2773		-0.29	9257		1.24	17,092	**	4.28
y98	4349		0.46	9545		1.3	7922	**	2.04
distance (feet)	50.67	**	3.75	21.62	**	4.44	10.09	**	8.76
distance^2	-0.0083	**	-2.15	-0.0004		-0.52	-0.0002	**	-2.81
y91_dist1	12.11		1.04	-1.88		-0.39	-6.64	**	-5.52
y91_dist2	-0.0059		-1.77	-0.0004		-0.57	0.0003	**	3.49
y98_dist1	4.03		0.35	-2.42		-0.52	-3.33	**	-2.85
y98_dist2	-0.0034		-1.04	-0.00018		-0.25	0.00013		1.45
old	-782	**	-14.58	-648.04	**	-10.76	-1386	**	-41.66
old^2	2.34	**	4.34	3.89	**	6.09	10.55	**	28.24
bfd_none	13,818	**	5.02	28,204	**	13.46	25,125	**	21.75
bfd_restrict	-90,138	**	-7.10	-13,667		-1.27	121,908	**	2.83
ann03	32,668	**	2.51	88,918	**	9.99	-8644		-0.2
ann03_dist1	-39.44	**	3.06	-30.86	**	-6.58	-0.06		-0.06
ann03_dist2	0.0086	**	2.37	0.0016	**	1.43	-0.0004	**	-4.54
site_dev	85,279	**	6.47	47,044	**	4.11	12,593	**	2.28
dev_dist1	-63.95	**	-4.07	-19.39	**	-2.58	-5.99	**	-3.4
dev_dist2	0.0108	**	2.4	0.0016		1.43	0.0005	**	3.6
bfdensity	1012	**	1.28	1601	**	2.3	411.09		0.89
bfshape_area	-0.128	**	-7.50	0.021		1.69	0.049	**	30.37
	R2=0.46		N=6033	R2=0.49	N=24,411		R2=0.52	N=134,047	
Brownfield fixed effects included in regression, but not reported. ** sig. ≥ 95%									

Table 8: Summary of Direct Effects of Linear Model—Sign and Significance--of Brownfields and Brownfield Redevelopment on Price and Assessment Value of Single-Family Residential Housing

	Sales 1991, 1998, 2003 (Table 3)	Sales 1991-2005 (Table 5)	Assessment 1991, 1998, 2003 (Table 6)
Distance from Nearest Brownfield			
0.5 mile	+	+ **	+ **
1 mile	-	- **	+ **
2 miles	+ **	- **	+
Site Development			
0.5 mile	-	+ **	+ **
1 mile	+ **	-	+
2 miles	+	-	+

Table A1: Direct Effects (Hedonics Included) of Brownfields and Brownfield Redevelopment on Log of Assessed Value (lnyearfa)

1991, 1998, 2003

	One-half mile			One mile			Two miles		
	Parameter estimate	Sig.	t value	Parameter estimate	Sig.	t value	Parameter estimate	Sig.	t value
intercept	11.13	**	40.47	9.2	**	87.1	9.55	**	383.38
y91	-0.102		-0.86	0.027		0.54	-0.013		-0.53
y98	0.1124		0.97	0.043		0.89	-0.103	**	-4.49
distance (feet)	-0.0001		-0.64	0.00003	**	8.18	0.00004	**	6.32
distance^2	5.74E-08		1.21	-2.44E-08	**	-5.01	7.89E-11		0.16
y91_dist1	0.0001		0.87	0.00002		0.53	0.00001		1.5
y91_dist2	-4.01E-08		-0.97	-5.00E-09		-1.06	-2.21E-09	**	-4.2
y98_dist1	-0.0001		-1.04	-0.00001		-0.42	0.00003	**	4.66
y98_dist2	4.14E-08		1.02	-1.20E-09		-0.26	-3.40E-09	**	-6.66
old	-0.0016	**	-2.35	0.006	**	14.1	0.005	**	26.77
old^2	-0.00004	**	-5.65	-0.00008	**	-18.61	-0.00008	**	-35.43
shape_area	0.000002	**	19.89	0.000002	**	32.92	0.000001	**	62.79
fullbaths	0.186	**	15.34	0.2	**	33.17	0.238	**	92.97
bedrooms	0.227	**	25.85	0.228	**	49.31	0.219	**	103.61
bfd_none	0.014		0.41	0.093	**	6.74	0.005		0.71
bfd_restrict	-0.933	**	-5.95	-0.021		-1.69	0.871	**	3.44
ann03	-0.2		-1.24	0.669	**	11.37	0.065		0.26
ann03_dist1	0.0004	**	2.53	-0.0002	**	-5.88	-0.00005	**	-7.96
ann03_dist2	-1.14E-07	**	-2.54	1.11E-08	**	2.39	1.83E-09	**	4.02
bfsite_dev	0.932	**	5.72	0.552	**	7.29	-0.149	**	-4.58
dev_dist1	-0.0008	**	-4.18	-0.0004	**	-7.7	0.00003	**	3.27
dev_dist2	1.68E-07	**	3.02	5.81E-08		7.7	-2.46E-09	**	-3.16
bfdensity	0.036	**	3.71	0.031	**	6.74	0.008	**	3.08
bfshape_area	-1E-06	**	-5.62	1.53E-07		1.86	3.88E-07	**	48.67
	R2=0.54	N=6033		R2=0.59	N=24,411		R2=0.64	N=134,047	
Brownfield fixed effects included in regression, but not reported. ** sig. ≥ 95%									

Table A2: Full Effects (Hedonics Omitted) of Brownfields and Brownfield Redevelopment on Log of Assessed Value (lnyearfa) 1991, 1998, 2003

	One-half mile			One mile			Two miles		
house price (not logged) indprice	Mean Value *Not re-run*		t value	Parameter estimate		t value	house price (not logged) indprice		t value
intercept	12.03507	**	38.73	9.87501	**	82.33	10.30696	**	360.88
y91	-0.03531		-0.26	0.06473		1.15	-0.00888		-0.33
y98	0.1866		1.42	0.10438		1.89	-0.08791	**	-3.38
distance (feet)	9.90E-05		0.52	0.000319	**	8.69	9.96E-05	**	12.91
distance^2	2.76E-08		0.51	-2.22E-08	**	-4.01	-2.30E-09	**	-4.1
y91_dist1	5.73E-05		0.35	-1.70E-05		-0.48	-1.80E-06		-0.22
y91_dist2	-3.76E-08		-0.81	-1.13E-09		-0.21	-1.40E-09	**	-2.33
y98_dist1	-0.00019		-1.2	-5.10E-05		-1.45	2.16E-05	**	2.76
y98_dist2	3.88E-08		0.84	5.55E-09		1.05	-2.72E-09	**	-4.67
old	-0.00658	**	-8.75	0.000373		0.82	-0.00258	**	-11.6
old^2	-1.40E-05		-1.89	-3.70E-05	**	-7.75	-1.50E-05	**	-5.87
bfd_none	0.05281		1.37	0.08028	**	5.09	-0.0201	**	-2.6
bfd_restrict	-0.95144	**	-5.35	-0.12536		-1.54	1.35608	**	4.71
ann03	-0.01307		-0.07	0.85318	**	12.73	-0.04337		-0.15
ann03_dist1	0.000251		1.39	-0.00018	**	-5.19	-9.20E-05	**	-12.84
ann03_dist2	-7.80E-08		-1.54	1.53E-09		0.29	3.59E-09	**	6.92
site_dev	1.25734	**	6.81	0.75699	**	8.79	-0.07993	**	-2.16
dev_dist1	-0.00107	**	-4.86	-0.00047	**	-8.31	7.06E-06		0.6
dev_dist2	2.11E-07	**	3.34	6.54E-08	**	7.61	-4.03E-10		-0.45
bfdensity	0.01845		1.66	0.03093	**	5.91	0.01164	**	3.78
bfshape_area	-0.000001	**	-5.17	3.48E-7	**	3.71	6.59E-7	**	60.72
	R2=0.40		N=6,033	R2=0.59	N=24,410		R2=0.53	N=134,036	

Brownfield fixed effects included in regression, but not reported. ** sig. ≥ 95%

Appendix 3

Pushing The Brownfields Envelope: Moving Towards Sustainability In Brownfields Policy

ACSP 2007, 48th Annual Conference
Building Ladders to the Middle-Class: Planning for Equitable and Sustainable Prosperity

October 18 – 21, 2007

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Since the mid-1990s, brownfields expertise has increased in both the public and private sectors—leading to more cleanups and reuses across the country. More sophisticated investors, better public policies, private-sector innovation and cheaper, more effective cleanup technologies have lowered environmental uncertainty. Thus, mainstream developers--rather than solely niche developers and public sector entities--are more comfortable investing in brownfields properties than in the past. With each successful brownfields redevelopment, the stigma once associated with redeveloping contaminated sites lessens.

A recently produced study partially funded by EPA, Envision Utah, points out how the market for brownfields redevelopment has matured.

"Yet unlike years past, the methods of studying contaminated land have become much more precise, and the techniques used to remediate environmentally distressed properties have matured with more successful and predictable results. Today, government programs and assistance are also widely available to assist those interested in the redevelopment of a brownfields property, and there are many competent consultants, attorneys, and others who can assist throughout the process" (5).[36]

Yet, brownfields policy is still geared towards promoting economic development on slightly contaminated sites. The assumption remains that contamination and uncertainty are the primary obstacles to redevelopment. Thus, public subsidies are needed to coax reinvestment. This mindset was valid in the 1990s when any redevelopment outcome was hailed as a success. Lost in this perspective is the reality that brownfields are environmental and community liabilities, not solely economic development conundrums. Public funds and programs should be targeted towards transitioning environmental and community liabilities into community assets that provide a variety of benefits beyond those that can be measured in strictly economic terms. This paper will explore brownfields redevelopment practices in Charlotte, NC from a sustainability perspective. About 50 redevelopments are critically reviewed on the environmental and sustainability merits of the outcomes. In the conclusion, policy recommendations are given for moving the brownfields paradigm to a more ecologically-centered program that turns environmental liabilities into community environmental assets.

Sustainability

What is a sustainability perspective? This is a particularly relevant question given society's embrace of "green" products ranging from organic foods to free range chickens to green urbanism. Focusing events like climate change has raised the public's awareness of sustainability. Planners are keenly aware of the links between community design and public health (cites). Defining sustainability and transferring it to a brownfields context, though, is especially difficult. The mere transformation of an environmental stigma into a productive economic asset certainly fulfills one component of sustainability. Recycling land is a worthy social goal. However, quantifying a sustainability benefit remains illusive and, for it to have policy ramifications, it must be measurable or at least identifiable. In addition, sustainability needs to be incorporated into comprehensive plans, federal programs and state programs if we are to realistically move towards a more sustainable future.

Campbell's sustainability triangle, while simple, is a good start for understanding the interaction of economic, ecological and equity goals (2005). In a neo-liberal policy environment, the appeal of consuming (economic) while protecting the environment and empowering communities is strong. The idea of promoting development outcomes that achieve integrated benefits supportive of people, prosperity and the planet is also vogue among federal agencies (EPA 3P

[36] http://www.envisionutah.org/resourcesfiles/47/Brownfield%20Redevelopment%20Toolbox.pdf

program). Within the economics literature, the concept of the triple-bottom line is also popular (cite). Consumers and producers alike are enamored at the concept of generating profit while being a good environmental steward (e.g., socially responsible investments). That is, society can have economic growth while promoting equity (new jobs, affordable housing) and the ecology (low-impact development). Brownfields are especially relevant parcels of land in the sustainability debate. They often times are located in communities lacking reinvestment, are checks against greenfield development and, depending upon the end-use, can radically alter existing socio-economic conditions.

Literature Review

During the 1990s, a growing literature developed that analyzed the relationship between environmental stigma and property values (Patchin, 1991; Mundy 1992; Chalmers & Roehr, 1993; Patchin, 1994; Roddewig, 1996). While lacking proper methodologies for measuring the true value of stigma, cities pushed for policies to overcome brownfields redevelopment obstacles (Bartsch, 1997). Stigma represented an urban competitive disadvantage relative to more pristine suburban greenfield sites. This drove many of the public sector responses to overcoming barriers to brownfields redevelopments (Bartsch, Meyer, Chilton, etc.)

Simultaneously, analysts started focusing on the environmental justice of hazardous waste sitings (Bullard, 1994). From an economic perspective, property values were thought to be negatively affected by contamination. From a policy perspective, locally unwanted land uses (LULUs) typically followed the path of least political resistance—low-income communities of color (Saegert, Thompson & Warren, 2001). As cities attempted to revitalize their urban cores in the early 1990s, both environmental justice and environmental stigma became obstacles to redevelopment. Brownfields tended to be located in low-income communities suffering from decades of disinvestment. Cities needed to reclaim that land in order to attract human capital and compete in the global economy. The popularity of Richard Florida's creative class thesis, for example, highlights the demand for urban lifestyles in dynamic, vibrant places.

Bartsch, Collaton and Peppers (1996) estimated that over 600,000 contaminated properties languished in US cities in the 1990s. While many of these sites were located in prime locations, the majority were situated in areas that had not experienced much market demand. States reacted by implementing state brownfields cleanup programs that limited developer liability (Bartsch). Despite these efforts, some developers remained concerned about additional federal oversight. To date, federal reopening of state cleanups has proven to be a non-issue (Simons and Winson-Geideman, 2003). Yet, policies tend to be monolithic and treat all brownfields sites as equals. This perspective ignores market conditions, levels of contamination or overarching neighborhood environmental burdens.

A stream of brownfields literature focuses on the property value impacts of contaminated sites. Jackson (2002) studied industrial brownfields and discovered that contamination reduces property values, but only temporarily. Schoenbaum (2002) studied the impacts of brownfields on property values in Baltimore and found limited evidence. Longo and Albarini (2005) also studied Baltimore and made similar conclusions. Namely, commercial and industrial properties were largely unaffected by proximity to brownfields according to their hedonic model. Corona's (2005) Connecticut study used hedonic modeling to determine the impacts of brownfields on residential property values. He found that proximity to brownfields decreases property values.

Howland's (2003) analysis of brownfields found that context matters. In areas with strong markets and light contamination, brownfields redevelopment is more likely to be private-sector driven. In contrast, neighborhoods with weak markets require stronger subsidies. The use of environmental insurance can be a tool for managing risk in both weak and strong markets (Wernstadt, Yount & Meyer, 2003; Meyer & Chilton, 1998). DeSousa (2002) takes a different angle and explores the catalytic role of brownfields in greening environmentally-tainted urban environments. Others are examining the public health impacts of brownfields redevelopments (Greenberg, 2003; 2002). The financial services industry has also reacted to the growing awareness of environmental risk management. The Environmental Bankers Association "was established in 1994 in response to heightened sensitivity to environmental risk issues, and the need for environmental risk management and due diligence policies and procedures in financial institutions."[37]

Moving beyond traditional economic cost benefit analyses seems to be a growing trend in the literature and in practice. The EPA has formed a bilateral working group with Germany to develop more well-rounded brownfields programs that consider social aspects of brownfields redevelopments.[38] EPA's Smart-e program explicitly recognizes that "revitalization of potentially contaminated sites should contribute to restoration of natural productivity, native biodiversity, parent soils, water quality, air quality, and social and economic equity. Sustainable revitalization is a holistic approach that considers more efficient use of resources with more profitable economic activity." EPA's P3 program is another example of more balanced approaches to redevelopment. According to the request for applications, "The P3 Awards program is a partnership between the public and private sectors to progress toward sustainability by achieving the mutual goals of economic prosperity, protection of the natural systems of the planet, and providing a higher quality of life for its people."[39]

As Wernstadt, Heberle, Albarini and Meyer (2004) point out, "Each brownfield redevelopment decision itself can trigger a variety of concerns related to the long-term vision of a community, threats to public health and nature, economic livelihoods, social equity, and public participation. Addressing these concerns in an integrated fashion at the intersection of social, economic, and environmental forces in principle would exemplify the expansive view of brownfields redevelopment as a palliative to the environmental and social stresses of urban America" (p. 7).[40] What's missing, at present, is a methodology for integrating the social, economic and environmental variables associated with brownfields redevelopments. Our research endeavors to build upon EPA's efforts to develop better methodologies for measuring the social, economic and environmental issues associated with redeveloping brownfields.

Sustainability Overview

While difficult to define, "sustainability" is becoming main stream. The application of sustainability doctrine, however, remains piecemeal and fractured. Sustainability means different things to different constituencies. The following table breaks down several constituencies and their major motivations when approaching a development. As the table shows, the emphasis is typically on economic factors that are measured in dollars.

Constituency	Concern
Developer	Return on Investment; shareholder value
Planner	Public health & safety; quality of life
Architect	Design quality; client satisfaction
Financier	Mortgageability; Repayment
Consumer	Value; Bang for the buck

[37] www.environbank.org
[38] See the "Smart-e" website for more information: http://www.epa.gov/brownfields/tools/tti_smarte.htm
[39] http://www.epa.gov/P3
[40] Available at: http://www.rff.org/Documents/RFF-DP-04-46.pdf

Politician	Economic Development; jobs; votes

Thus the conundrum facing advocates of sustainability. Can new paradigms that explicitly value difficult to quantify benefits compete with the existing models of cost-benefit analysis? Some consider sustainability to be a backdoor means by environmentalists to limit economic output. Yet, this hysteria is not warranted. Sustainability recognizes the critical role that economic success plays in a balanced community development program. It seeks outcomes that have positive social and environmental outcomes as well. As the sustainability triangle below shows, a better balance between profits, people and pollution is an implicit goal for sustainability advocates.

Planners and policy-makers, like Chicago's Mayor Daley, invoke sustainability as a concept to drive future growth and development. Recycling contaminated land is one prong of a broader sustainability agenda. At its essence, sustainability requires the application of best practices in development, design and technology to efficiently use or reuse scarce resources. While the concept remains fuzzy, some overlap exists in terms of a generic definition.

The Bruntland Commission (1987) defined sustainable development as "*development that meets the needs of the present without compromising the needs of future generations to meet their own needs."* The Bruntland definition provides a framework for sustainability that is based upon inter-generational equity and environmental justice. Of course, a measurement scheme does not accompany the definition. The task of building more holistic methodologies that can value less tangible social goods has been left to policy-makers and academics.

A revised definition of sustainability by Pearce, Makandia, and Barbier (1989) provides a more clear elaboration of the concept:

Sustainable development involves devising a social and economic system, which ensures that these goals are sustained, i.e. that real incomes rise, that educational standards increase, that the health of the nation improves, that the general quality of life is advanced.

Pearce et al.'s definition provides more substance and furthers the emphasis on both social and environmental justice. Extrapolating from this definition, analysts can start to build tools that measure different facets of sustainability. We have passable measures of income advance, educational attainment and performance, physical health outcomes and proxies for quality of life. All of these type measurements can be applied to valuing public investments in brownfields redevelopment.

The website Sustainablemeasures.com[41] simplifies the literature on sustainability as follows:

All the definitions have to do with:

- Living within the limits
- Understanding the interconnections among economy, society, and environment
- Equitable distribution of resources and opportunities

Again, the definitions are simple and direct, but they lack specificity. The interconnections between the economy, society and environment are multiple and complex. If fully understood, how would the relative merits compare to one another? Gaining consensus on the meaning and

[41] http://www.sustainablemeasures.com/Sustainability/Definitions.html

merits of equitable distribution would likely be impossible. Esty (2001) contends that for environmental decision-making to progress, we need better indicators and metrics.[42] To that end, the Yale Center for Environmental Law and Policy has established a global Environmental Sustainability Index (ESI). The ESI is composed of 76 variables, 21 indicators and 5 components.[43] The first component, Environmental Systems, examines biodiversity and land, water and air pollution. The second component, reducing environmental stresses, deals with reducing various pollutants, reducing environmental stressors, population pressure, and environmental management schemes. The third component concentrates on reducing human vulnerability to environmental problems. Social and institutional capacity is the fourth component of sustainability, and encompasses both the public and private sectors. Finally, global stewardship is considered. The indicators of global stewardship include greenhouse gas emissions per GDP or per capita, participation in environmental collaborations and the like. While the ESI focuses on nations, similar indexes could be constructed for regions. The tool would be a powerful mechanism to compare regional environmental performance across a host of variables.

At the community level, cities have striven to produce sustainability reports using data collected at the local level. The purpose of these endeavors is to give policy-makers and community members better decision-making tools. Charlotte has an on-going neighborhood analysis report titled City-within-a-City (CWAC). CWAC collects economic, crime, social and education data for neighborhood statistical areas (NSA's) every two years. Each NSA is ranked on all factors and is labeled *Stable*, *Transitioning* or *Fragile*. Local leaders can use the data to examine NSA-level trends and determine areas of instability and focused policy interventions.

In this paper, we have combined CWAC data with brownfields data to perform numerous statistical tests on neighborhood level variables. Some of these data are presented in the following section. However, the results have not been spectacular, to date. The limited results suggest that the presence and or redevelopment of brownfields in a neighborhood does not significantly predict community reinvestment. We will present some evidence that reinvestment in Charlotte NSA's with brownfields is affected by traditional variables impeding reinvestment: crime, race and poverty.

Rather than spending a lot of time on the statistical analysis, it is important to keep in mind the value of CWAC type databases, in general. At a minimum, exploring the interaction of brownfields reinvestment with neighborhood indicators of school performance, crime rates, public sector community investment, percentage of children receiving free or reduced lunches, availability of basic retail, etc. adds a new layer of complexity to brownfields redevelopment that moves away from a strict economic bias.

Brownfields in Charlotte

Charlotte is an interesting city for studying brownfields. The economic and social history is vastly different from many rustbelt cities. Charlotte has experienced tremendous growth over the last 15 years. During that time, hundreds of thousands of new residents from across the globe have made Charlotte their home. The downtown area (known as Uptown), inner-ring suburbs and surrounding counties have all experienced rapid transition and tumultuous growth. A recent Charlotte-Observer article pointed out that more than 50 percent of Charlotte's population is

[42] Daniel Esty. September 21, 2001. "Toward Data Driven Environmentalism: The Environmental Sustainability Index. *The Environmental Law Reporter News and Analysis*, Environmental Law Institute.
[43] The report can be downloaded at: http://sedac.ciesin.columbia.edu/es/esi/ESI2005_policysummary.pdf

composed of those not born here. Lured by a strong economy and banking industry, Charlotte boasts a high rate of educational attainment (about 40 percent). While impressive from a human capital perspective, many of the newcomers know little of Charlotte's history as a textile town. They are blissfully unaware of the presence of brownfields given their lack of familiarity with Charlotte's history and geography.

Unlike rustbelt cities, Charlotte does not have a large number of obvious brownfields sites. Driving through older parts of town, one is not greeted by decaying industrial sites. The visual cues associated with many industrial cities are non-existent in Charlotte. Consequently, awareness of brownfields by young professionals seeking a dynamic lifestyle in Charlotte's core or gentrifying neighborhoods is lacking. Prior to the recent real estate downturn, Charlotte has had no difficulty attracting capital and residents to formerly rundown areas of town. Brownfields have been utilized in various ways ranging from condominiums to mixed-use office and commercial. Another ingredient that distinguishes Charlotte from some cities is the absence of strong community development organizations (CDCs). Granted, CDCs operate within Charlotte, but they do not seem to play a large role in the fast-paced urban redevelopment arena. The city of Charlotte has successfully implemented several HOPE VI projects in and around the city with little opposition. In short, Charlotte has been classified by many as a developer-friendly town and one of the biggest power brokers in the city is the Real Estate Building Industries Council (REBIC). REBIC has been a strong advocate of redevelopment throughout the region, and uses its money and power to support political candidates who share REBIC's laissez-faire development attitude.

Charlotte markets have not been negatively affected by challenged real estate or brownfields. At present, over 3.8 million square feet of office development, 658,000 square feet of retail and over 6,000 addition housing units (about 2.9 billion dollars estimated cost) is proposed or under construction in Uptown Charlotte. The population in Uptown has grown from 5,900 in 2000 to over 10,000 in 2005. An estimated 20,000 residents will populate Uptown by 2010.[44] This magnitude of development has spilled out into older neighborhoods around the urban core, promoting gentrification in older historic neighborhoods like North Davidson, Wilmore, Wesley Heights, Elizabeth and Southend. Within a one-mile radius of Uptown, population has also more than doubled since 2000. The city has been instrumental in promoting development through targeted investments in a light rail system, Uptown basketball arena, Uptown baseball stadium, a NASCAR museum and working with private developers to reuse brownfields for urban infill. While successful in terms of economic development, few voices in Charlotte are asking about the impacts of this development on low-income and working class residents of Charlotte. Similarly, few voice concerns about the sustainability of the downtown growth strategy. It is assumed that light rail and denser urban villages will yield more sustainable outcomes than suburban sprawl. Perhaps this is true, but critical examination of Charlotte's urban growth and the role of brownfields in that growth remains unarticulated.

The purpose of this data is to convey the scale and scope of real estate development in Charlotte. Given demand for property in and around Uptown, brownfields is not an obstacle to private sector actors. Over 40 properties in Charlotte have taken advantage of North Carolina's brownfields program. While Charlotte has a respected comprehensive plan, it lacks a strong sustainability component. Charlotte is noticeably lacking in parks and greenspace, for instance. Community design standards exist, but Charlotte's General Development Principles are strictly a framework for guiding future development. I contend that Charlotte could be a leader in more sustainable brownfields redevelopment given the growth context outlined here. It is easier to

[44] All Uptown Charlotte data can be found at the following website: www.charlottecentercity.org

impose stricter requirements in hot real estate markets than in markets experiencing disinvestment. Davidson, North Carolina, for example, has implemented an inclusionary zoning ordinance to promote affordable housing in all future developments. Why? Because they can. I am arguing that Charlotte is missing a tremendous opportunity to leverage additional ecological, environmental and social benefits from their existing brownfields inventory by not taking advantage of Charlotte's advantageous real estate market dynamics.

In theory, Charlotte is dedicated to implementing sustainable practices as part of its land use development. The Charlotte-Mecklenburg County Planning Department's website claims the following: "Charlotte will safeguard the environment, balancing health, sound fiscal policy, and growth." In short, this commitment echoes a strong holistic philosophy towards sustainable growth. In addition, the North Carolina Brownfields Program mandates a "public benefit" as part of the rationale for providing funding or liability relief for brownfields redevelopment. Unfortunately, the state provides no additional guidance on what constitutes a public benefit. No type of environmental benefit is mentioned in the legislative text. Likewise, the Charlotte language is weak and lacks a regulatory framework to achieve sustainable outcomes.

In the following sections, we will highlight economic, social and environmental/ecological benefits of brownfields redevelopment in Charlotte. Following that, a discussion of policy implications and ramifications for future research is presented.

Economic Benefits

As Map 1 shows (see appendix), a rudimentary brownfields corridor exists along Charlotte's South Boulevard. This area has undergone a tremendous amount of reinvestment over the last 10 years. Sparked by one private developer, South Boulevard contains several flagship brownfields redevelopments and continues to gentrify, attracting young professionals and additional investment related to ongoing light rail construction (slated to open in November 2007). Most of the redevelopments are mixed-use and driven by the private sector. Charlotte's public sector has laid the groundwork through investments in transit and place-making. The private sector has responded by redeveloping brownfields. None of the private redevelopments has been sponsored by Cherokee Investment Partners or any other specialty brownfields redeveloper.

As Figure 2 (see appendix) indicates, a surge in condominium building permits has accompanied much of the Uptown and South Boulevard redevelopment. Again, this pattern of investment fits well with Charlotte's stated policy of transit-supported development along major transportation corridors. While it is difficult to allocate credit to brownfields redevelopment for these trends, it is clear that brownfields properties have not been an impediment to redevelopment. In fact, we performed a regression analysis using building permit value (in dollars) as the dependent variable. Independent variables included the following:

- Median Household Income
- Mean House Value
- Violent Crime Rate
- School Competency Scores
- Dropout Rates
- Race
- Presence of Brownfields (dummy variable)

In our analysis, the presence of brownfields was not a statistically significant predictor of reinvestment in low-to-moderate income communities. In fact, as Table 1 shows, we found that neighborhoods with brownfields have attracted more residential and non-residential investment per capita than neighborhoods without brownfields in Charlotte. Overall, the evidence suggests that brownfields redevelopment in Charlotte has successfully contributed to local economic development efforts in the city.

Table 1: Reinvestment in Low-to-moderate Income Census Tracts: 2000 – 2005

	w/Brownfields (9)	Without Brownfields (56)
Total Population	15,382	163,826
Total Residential Permit Value	$97,946,054	$513,525,452
Per capita Residential	$6,368	$3,135
Total Non-Res. Permit Value	$233,668,845	$462,360,434
Per capita Non-Residential	$15,191	$2,822

Environmental & Ecological Benefits

The CWAC data does not include environmental quality data. In fact, it is difficult to find any environmental data that is collected a small scale that is transferrable to statistical analysis. However, we do know that only 15 of the brownfields sites redeveloped required any site remediation (Godwin and Wang, 2007, unpublished). The high number of mixed use and residential outcomes on brownfields sites suggest that environmental contamination has not been a major threat.

None of the redevelopments in Charlotte have led to outcomes providing parks, open space or other public uses that contribute to the ecological quality of neighborhoods. In addition, none of the brownfields redevelopments in Charlotte have produced LEED-certified buildings. As mentioned earlier, some of the developments have certainly recycled older, historic buildings in Charlotte. It would be unfair to downplay this benefit because Charlotte is considered a failure by some in terms of preserving historic sites. Reusing old mills along South Boulevard and within NODA's arts district has anchored newer developments into the fabric of the community's history. While significant for these neighborhoods, these types of brownfields projects have been the exception rather than the norm.

Human health considerations have not been part of the brownfields redevelopment debate in Charlotte. Directors from Charlotte's Health & Human Services Department have informed us that no one has inquired about health data in and around brownfields sites. Currently, our research team is examining the correlation between premature births and mortality rates around brownfields sites. To date, though, human health seems to be ignored. Perhaps, it is assumed that the Department of Environment and Natural Resources (DENR) is engaged in due diligence on behalf of neighborhoods affected by brownfields sites.

Social Benefits

Defining social benefits is difficult, and social benefits often overlap economic benefits. For instance, property tax revenue that could support local social programs has been generated by brownfields redevelopments. Local residents who have been unemployed or under-employed have likely found jobs in LMI neighborhoods experiencing substantial reinvestment. Other variables, though, like school performance, crime rates and social capital have not been part of the criteria for examining redevelopment success. Map 3 shows the location of brownfields by the racial concentration of the neighborhood. Rather than focusing solely on race, we used CWAC data to create a *hotspot* map that focuses on the following variables:

- Median Household Income
- Average House Value
- Non-white Population
- Violent Crime Rate
- Student Competency Scores
- Percent Population using Food stamps

The map aggregates all of these factors into a single map (appendix, Maps 4 & 5) that overlays brownfields on neighborhoods with the highest rates of poverty, crime, non-white racial concentration and low-house values. Many of the areas highlighted on the map have been by-passed by Charlotte's rapid growth. In some cases, neighborhoods west of Uptown have seen spikes of real estate speculation and scores of homes have been purchased and boarded up by speculators awaiting first-wave gentrifiers. A recently announced brownfields redevelopment in west Charlotte could be the spark that ignites the process. A contaminated site, Radiator Specialty, will be transformed into a mixed use development headquartering The Charlotte School of Law (private sector law school). Other projects nearby that are not on brownfields sites are already in-progress. Lost in the excitement about redevelopment has been the concern over existing residents. Where will they go? How will they fare in terms of affordable housing once new residents start moving in? Will they be forced to leave or allowed to stay and share in the success of the neighborhood? Since these questions are not being asked, it is unlikely that those who stuck with the neighborhood during its down years will share in the quality of life enhancements likely to accompany newer, more affluent in-migrants.

In order to better understand the role of socio-economic variables on community reinvestment, we performed two factor analyses (see appendix). The total value of non-residential building permits and total value of residential building permits in LMI neighborhoods were used as dependent variables. The factors used in the regressions are as follows:

- Total number of brownfields sites in each NSA
- Total acreage of brownfields sites in each NSA
- City capital investment in each NSA
- Neighborhood factor (variable composed from medium household income, average house value, violent crime, competency score, dropout rate, race)

In each analysis, neither the number of brownfields per NSA nor brownfields acreage per NSA was statistically significant predictors of building permit value. The factor variable was the only statistically significant predictor. While numerous methodological issues need to be ironed out, our preliminary results suggest that underlying socio-demographic and socio-economic conditions are driving forces affecting levels of community reinvestment. This is nothing new, but it seems to have been lost in the brownfields debate where the focus has remained on overcoming contamination issues, not community conditions.

Implications & Conclusion

The economic benefits of brownfields redevelopment cannot be denied. Inasmuch as community spinoffs occur and some cleanup is occurring, communities are likely better off after redevelopment than before. In terms of promoting a market-driven style of urban renewal, brownfields policies have been quite successful in Charlotte. Neighborhoods have changed dramatically as a host of public policies have reinforced one another to promote urban restructuring. If economic development is the goal, it would be hard to argue that brownfields policies have not been successful. Can brownfields policies be tweaked to achieve more broad-based environmental, ecological and social benefits? To date, the policy goals have not been changed to reflect new realities. The uncertainty concerns facing brownfields redevelopers in 1995 have been largely overcome by federal and state policies to incent brownfields redevelopment—especially in Charlotte, NC. Targeting brownfields dollars to those neighborhoods with distressed social and environmental conditions makes sense.

Using sustainability as a catalyst for wholesale community rejuvenation has not been attempted. Sustainable buildings, for instance, could provide reduced utility bills for working families that increases discretionary income. Investment in green buildings would also signal to the market that an area is truly in transition from an industrial past to a post-industrial future. Better design and site connectivity could promote community health goals. The list of potential benefits is long. At present, numerous public and private sector sustainability initiatives are being rolled out, but they are uncoordinated. Focusing these programs on LMI neighborhoods could be a new approach to community development, economic empowerment and environmental justice. Incorporating these goals into a brownfields program would be one step in coordinating these disparate initiatives.

Some might argue that burdening brownfields policies with additional requirements could impede their redevelopment. Greenfield sites, for instance, are not saddled with ecological or social policies, thus they are potentially more appealing sites for development than brownfields. We are arguing for a set of policy tools that recognize market context. Given the high level of demand for land in and around Charlotte's urban core, community leaders are in a strong position to use brownfields policy to further broad sustainability, affordable housing, quality of life and livability goals. Yet, neither federal nor state leadership has impelled a change in the status quo. At present, brownfields programs are sources of discretionary federal money used to seed urban renewal in Charlotte.

Working with EPA, we are attempting to provide policy-makers with a decision-matrix that can be used to comprehensively evaluate the merits of brownfields projects across multiple variables. The matrix is simple and flexible. For instance, it is up to community leaders and residents to weight factors by level of importance. As we have learned, what is important in Charlotte's context is unlikely the same in other cities. Thus, vigorous public participation forums are needed to determine what variables should be used to target public funds and programs.

Table 2, below, is rough guide to the types of variables that community leaders have access to that would facilitate better decisions and outcomes. We are not arguing that all of these variables are applicable to every brownfields project. Rather, these variables can be critical to approving redevelopments that provide numerous community development benefits. As our preliminary data suggests, many brownfields neighborhoods are struggling to attract reinvestment for a variety of socio-economic reasons—not because brownfields. Consequently, a community development approach to brownfields redevelopment is needed to deliver a range of benefits that promotes economic development, environmental stewardship and social empowerment.

Beyond Rhetoric

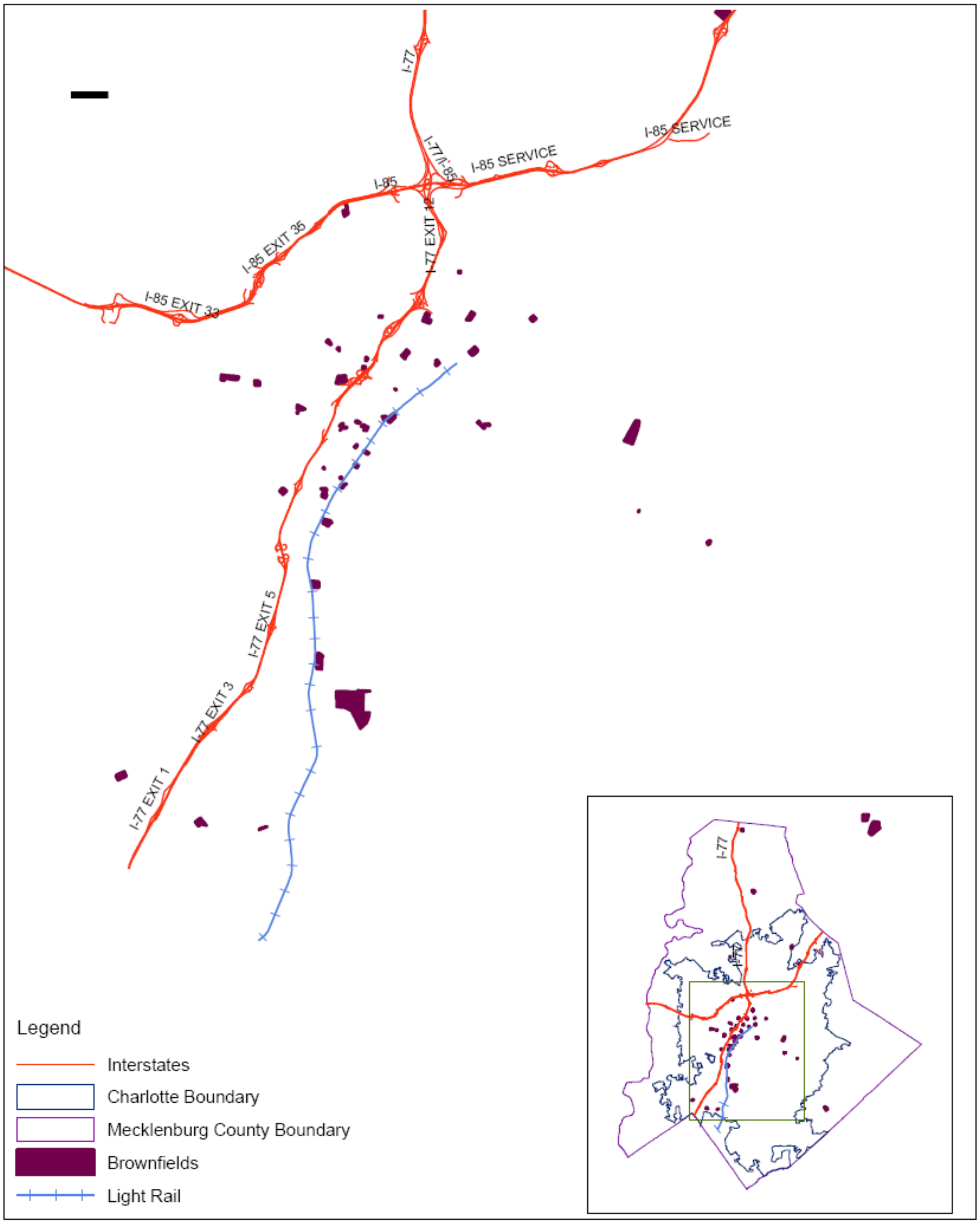
Political will is needed to mold strong policies focused on sustainable outcomes. Brownfields could be a catalyst for sustainable outcomes if policies are changed to encourage a different set of outcomes. First, the brownfields paradigm needs to shift. As mentioned earlier, the expectations for brownfields development have been low. Any redevelopment has been lauded as a success. The bar of success is set too low and federal leadership is needed to infuse sustainable development criteria into federal pilot programs.

Table 2: Proposed List of Brownfields Matrix Variables

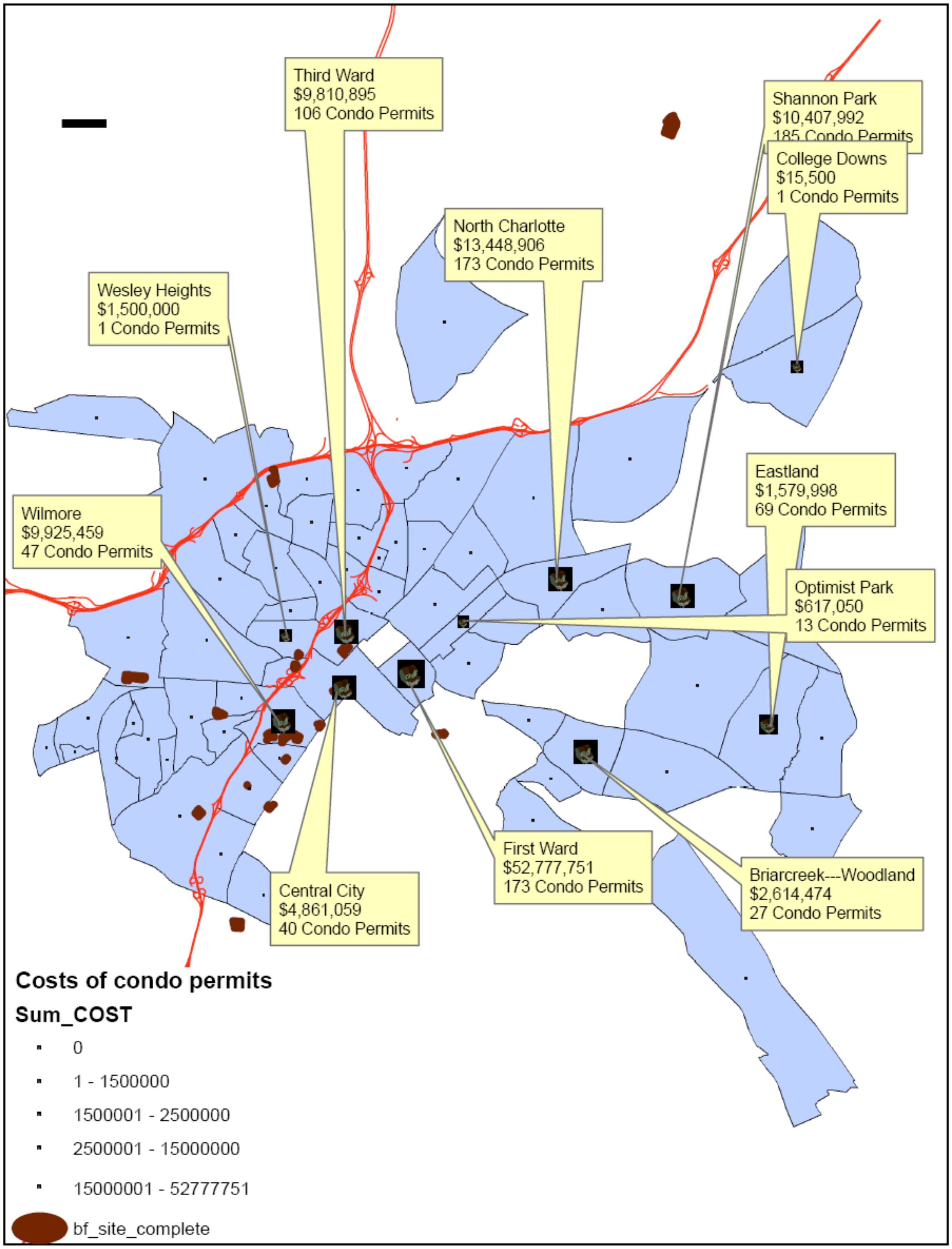
Percent persons over 64
Average Kindergarten Scores
Dropout Rate
Percent of children passing competency exams
Percent of births to adolescents
Youth opportunity index
Violent crime rate
Juvenile arrest rate
Property crime rate
Crime hotspots
Appearance index
Percent substandard housing
Percent homeowners
Projected infrastructure improvement costs
Percent of persons with access to public transportation
Percent of persons with access to basic retail
Pedestrian-friendly index
Percent of persons receiving food stamps
Percent change in income
Percent change in house value
Voter turnout
Building permit value (residential and non-residential)
Racial change
Open space/ park acreage
Low-weight births
Mortality rates (cancer)
Green design
Recycled content
Community design (LEED-ND)
Low-impact design
Connectivity

MAP 1

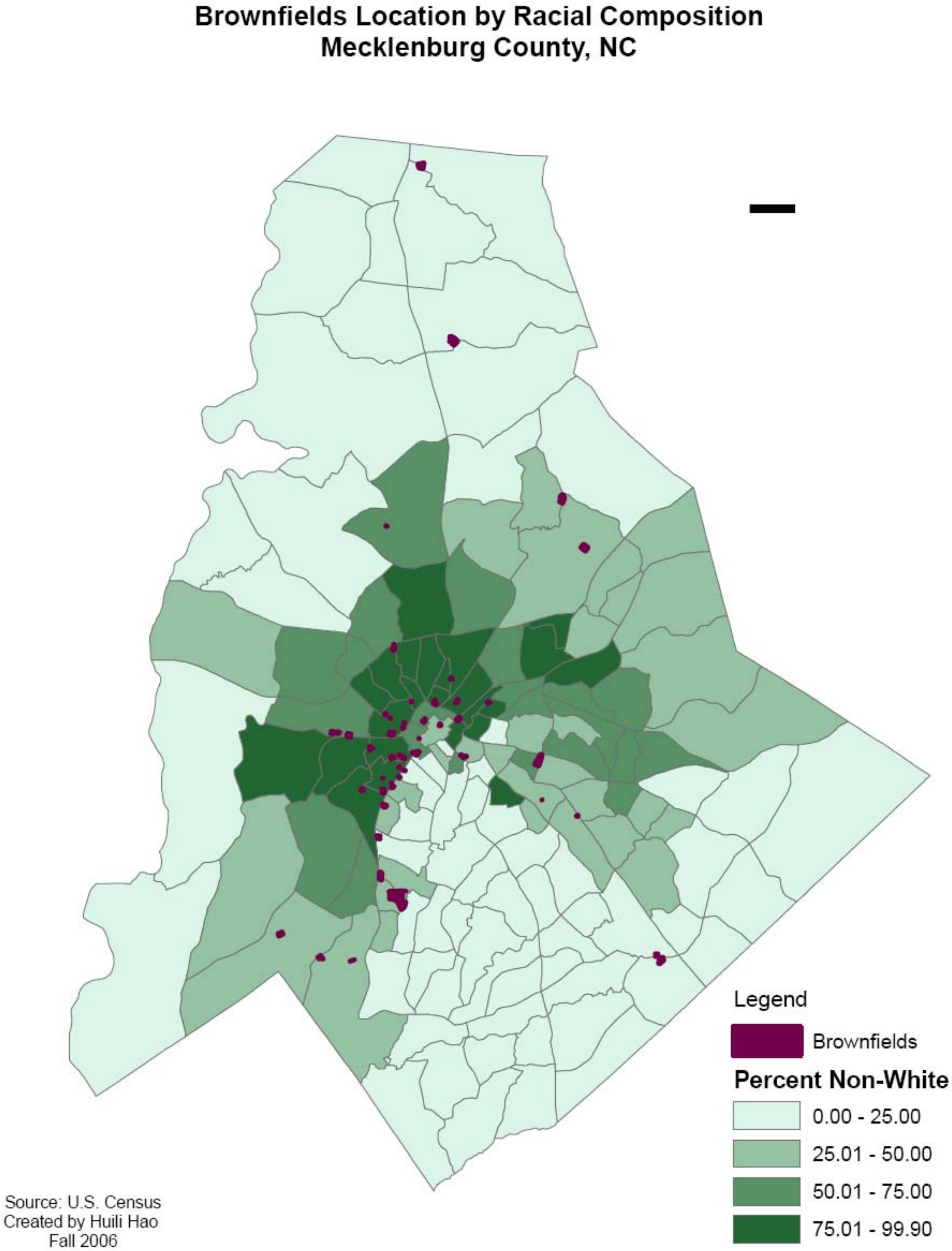
Location of brownfields sites in Charlotte, NC



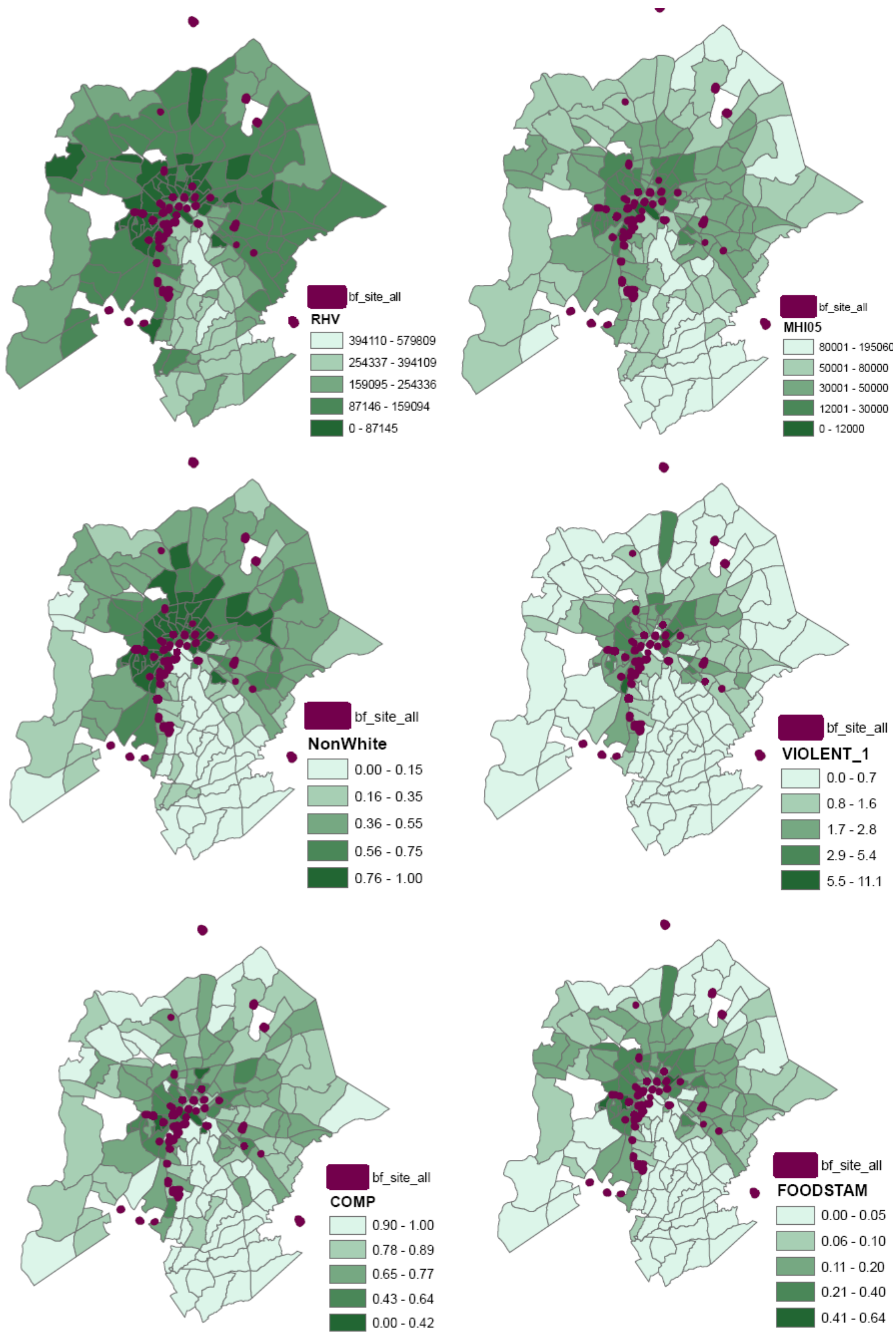
Map 2


Third Ward
$9,810,895
106 Condo Permits
Shannon Park
$10,407,992
185 Condo Permits
College Downs
$15,500
1 Condo Permits
North Charlotte
$13,448,906
173 Condo Permits
Wesley Heights
$1,500,000
1 Condo Permits
Wilmore
$9,925,459
47 Condo Permits
Eastland
$1,579,998
69 Condo Permits
Optimist Park
$617,050
13 Condo Permits
First Ward
$52,777,751
173 Condo Permits
Briarcreek---Woodland
$2,614,474
27 Condo Permits
Central City
$4,861,059
40 Condo Permits
Costs of condo permits
Sum_COST
0
1 - 1500000
1500001 - 2500000
2500001 - 15000000
15000001 - 52777751
bf_site_complete

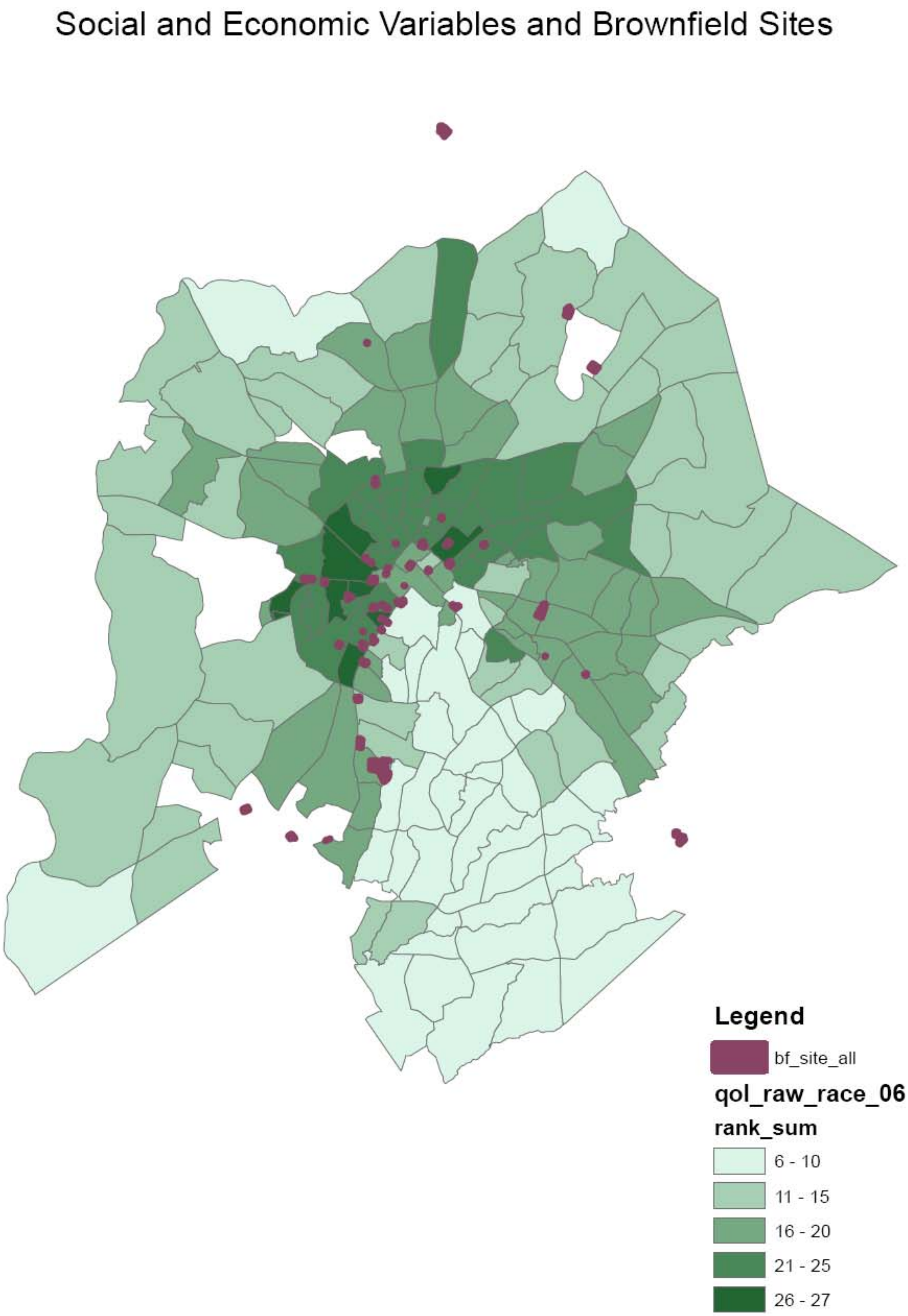
Map 3


Brownfields Location by Racial Composition
Mecklenburg County, NC
Legend
Brownfields
Percent Non-White
0.00 - 25.00
25.01 - 50.00
50.01 - 75.00
75.01 - 99.90
Source: U.S. Census
Created by Huili Hao
Fall 2006

Map 4


bf_site_all
RHV
394110 - 579809
254337 - 394109
159095 - 254336
87146 - 159094
0 - 87145
bf_site_all
MHI05
80001 - 195060
50001 - 80000
30001 - 50000
12001 - 30000
0 - 12000
bf_site_all
NonWhite
0.00 - 0.15
0.16 - 0.35
0.36 - 0.55
0.56 - 0.75
0.76 - 1.00
bf_site_all
VIOLENT_1
0.0 - 0.7
0.8 - 1.6
1.7 - 2.8
2.9 - 5.4
5.5 - 11.1
bf_site_all
COMP
0.90 - 1.00
0.78 - 0.89
0.65 - 0.77
0.43 - 0.64
0.00 - 0.42
bf_site_all
FOODSTAM
0.00 - 0.05
0.06 - 0.10
0.11 - 0.20
0.21 - 0.40
0.41 - 0.64

Map 5



Factor Analysis:

Dependent Variable: Total Assessed Value of Non-residential Building Permits per NSA: 2000-05

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2E+007	5876717		3.886	.000		
	bf_count	1732694	3484331	.066	.497	.621	.833	1.201
	Brownfield site total acres (from area calculation)	-19266.5	725010.9	-.003	-.027	.979	.861	1.161
	Infrastructure cost	-.610	.826	-.094	-.739	.463	.914	1.095
	REGR factor score (MHI, average house value, violent crime, comp, dropput, pct white)	1E+007	5628106	.302	2.409	.019	.938	1.066

a. Dependent Variable: Total assessed value of non residential building permits in each NSA (00-05)

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.338(a)	.114	.055	22471339.19658

a Predictors: (Constant), REGR factor score (MHI, average house value, violent crime, comp, dropout, pct white), Brownfield site total acres (from area calculation), Infrastructure cost, bf_count
b Dependent Variable: Total assessed value of non residential building permits in each NSA (00-05)

Dependent Variable: Total Assessed Value of Residential Building Permits per NSA: 2000-05

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2E+007	3458436		6.693	.000		
	bf_count	309992.5	2050522	.018	.151	.880	.833	1.201
	Brownfield site total acres (from area calculation)	-333404	426667.5	-.093	-.781	.438	.861	1.161
	Infrastructure cost	-.328	.486	-.078	-.674	.503	.914	1.095
	REGR factor score (MHI, average house value, violent crime, comp, dropput, pct white)	1E+007	3312129	.490	4.280	.000	.938	1.066

a. Dependent Variable: Total assessed value of residential building permits in each NSA (00-05)

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.511(a)	.261	.212	13224338.35020

a Predictors: (Constant), REGR factor score (MHI, average house value, violent crime, comp, dropout, pct white), Brownfield site total acres (from area calculation), Infrastructure cost, bf_count
b Dependent Variable: Total assessed value of residential building permits in each NSA (00-05)