Community assessment: understanding the built environment within a neighborhood health context

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April 24, 2009

Master of Environmental Management Candidate 2009

Ecotoxicology and Environmental Health

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Master's Project submitted in partial fulfillment of the requirements for the Master of Environmental Management degree in the Nicholas School of the Environment, Duke University 2009

Abstract

Purpose: Research shows evidence of associations between the built environment (BE)—housing, commercial buildings, community resources, and infrastructure—and health outcomes. However, there is less research describing the spatial variation of BE conditions. This master's project demonstrates the impact of this variation with a database describing the BE within a neighborhood health context.

Hypothesis: The hypothesis tested is two-fold: 1) the assessment tool enables the quantification of BE conditions, and 2) the data generated offer a comprehensive index for relating the BE to public health.

Methods: Trained assessors canvassed over 17,000 tax parcels in Central Durham, NC using a standardized visual assessment of 40 distinct BE variables. Data were summed into 8 indices—housing damage, property damage, security level, tenure, vacancy, crime incidents, amenities, and nuisances. Census blocks were assigned an index based on the summary score of primarily and secondarily adjacent blocks.

Results: The indices describe the spatial distribution of both community assets and BE conditions that are likely to affect the health of residents. Housing damage, property damage, security level, vacancy, crime incidents, and nuisances all contained higher scores for blocks located in areas characterized by high minority and low socioeconomic status. Similarly, a low tenure score described those same blocks, indicating that the majority of residential properties within those blocks are renter-occupied.

Conclusions: The community assessment tool offers a comprehensive inventory of the BE, facilitating the generation of indices measuring neighborhood health. These resulting data are useful to community members, researchers, and government leaders.

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Motivation for the study

In the United States, incidence rates of sexually transmitted diseases, obesity, and cardiovascular disease are all on the rise, resulting in an economic burden through direct and indirect costs associated with the healthcare system and loss of productivity (Centers for Disease Control and Prevention). In the United States, 7.3% of adults and 9.1% of children are currently diagnosed with asthma. Diabetes plagues 10% of adults over the age of 20, 11% of adults have cardiovascular disease, and 66% of adults, 17% of adolescents, and 19% of children are overweight (Centers for Disease Control and Prevention). High rates of diseases such as these with an identified environmental component in the causal mechanism add a degree of complexity to public health research due to varying methods of measurement and analysis of the environmental components.

Air and water quality are known to cause or contribute to a variety of adverse health effects and the science contributing to the measurement and analysis of the impact of the natural environment on human health is fairly well understood. However, less is known about the science directing the assessment of the impact of the built environment, or neighborhoods themselves, on public health. Some researchers have posited that neighborhood deprivation or disadvantage may be contributing to these rising rates. Social and demographic data have been used to quantify the level of deprivation or disadvantage characterizing neighborhoods. These data include indicators of socioeconomic status, crime rates, perceived stress, social capital, and access to resources. The resulting indices measuring neighborhood deprivation have been linked to the prevalence and incidence of cardiovascular disease (Augustin et al 2007, Elliot

2000, Hill et al 2005, Ross 2001). As a result, interest in neighborhood quality and the built environment has been growing rapidly.

Studies that investigate the role of neighborhood deprivation or neighborhood disorder in community health are limited by several factors: 1) inconsistent and varying methods for measuring neighborhood deprivation; 2) lack of methodology for systematically measuring neighborhood characteristics, and 3) lack of methodology for combining various neighborhood health variables into a meaningful index. While this neighborhood deprivation index provides a comprehensive analysis of the social environment of neighborhoods, it fails to consider the conditions of the physical environment that are believed to affect community health. In this master's project, I attempt to address these limitations by developing and documenting a comprehensive and systematic method for characterizing neighborhood health using built environment data.

Analysis of the neighborhood environment as a whole is necessary to conclusively measure the full impact of environmental conditions on community health. This requires the consideration of the built environment in addition to neighborhood deprivation. The term built environment refers to physical features of neighborhoods including housing, commercial buildings, parks, and infrastructure. Concurrently, community health is dependent on multiple factors: housing quality, access to health care, grocery stores and education centers, the presence of litter and sidewalks, and the types of commercial properties represented in an area. Detailed knowledge of these aspects of the built environment is beneficial neighborhood leaders, community groups, city officials and researchers. Few studies are based on data obtained from an objective assessment of the built environment, instead relying on surveys of

study populations to determine perceptions of social interactions and other neighborhood characteristics within neighborhoods (Buckner 1988, Coulton 1996, McGuire 1997). While these are important aspects of the built environment and are indicative of the health status of residents, analyses are limited by a lack of substantive data free from bias.

In addition, observation of the physical attributes of neighborhoods, the built environment, has primarily focused on northern urban centers (Caughy et al 2001, Raudenbush 1999, McGuire 1997, Perkins 1992, Kohen 2002) with the exception of a study in New Orleans (Cohen et al 2000). It can be argued that extrapolating results for the urban North to the New South is faulty due to variations in the physical and social structure of communities. While researchers continue to collect information on the built environment, no standardized method of collection exists despite similarity amongst included variables. Finally, researchers rarely link built environment data to census or clinical data.

The built environment can affect physical, mental, and emotional health, and it influences the quality of life for residents on multiple scales. While it may be intuitive to look at a stretch of road and determine that the condemned house and liquor bottles strewn about are likely to negatively impact the health of nearby residents, public health researchers lack systematic ways to assess the impact of these factors on health. In contrast, components of the built environment that are more easily measured, such as housing, urban design, community resources, and crime, have been linked to health outcomes.

Housing

Housing conditions are believed to affect health outcomes via multiple pathways including direct exposure to allergens, poor indoor air quality, volatile organic compounds (VOCs), chronic stress, and the facilitation of disease transmission (Bonnevoy et al 2003, Shaw 2004). Housing is also viewed as a proxy for socioeconomic status, especially in terms of tenure. Owner-occupied housing may be characterized by better housing quality and a more vested interest in community issues by residents (Shaw 2004).

Multiple studies have shown housing conditions to be associated with a variety of health outcomes. Inadequate housing quality has been associated with higher levels of psychological stress (Evans 2000), decreased children's socioemotional health (Gifford 2006), and increased rates of chronic illness (Habib 2009).

Urban Design

Urban cores and their suburbs tend to have distinct layouts that affect the health of residents. The core is more likely to be laid out in a grid pattern with a high degree of connectivity between residential areas and commercial centers accompanied by the presence of sidewalks. Suburban areas are more likely to follow a "loop and lollipop" pattern with fewer sidewalks. The loop and lollipop design decreases connectivity by isolating residential areas through cul-de-sacs and looping street segments that fail to provide a direct path from residential areas to commercial centers.

The walkability of a neighborhood, typically defined by the connectivity of residential areas to commercial areas, mixed land use, residential density, and the availability of sidewalks,

has been shown to be positively associated with physical activity levels of residents, and thus, decreases the prevalence of obesity (Frank 2005, Saelens et al. 2003, Ewing et al. 2003, Grafova 2008).

Community Resources

The availability and accessibility of resources such as health services, faith-based organizations, grocery stores, schools, and community centers are critical in maintaining healthy communities (Galea and Vlahov 2005, Grafova 2008, Papas et al 2007). Community resources that facilitate interaction among residents and physical activity may contribute to social capital. This social capital may be indicative of the socioemotional health of residents and may also aid in crime prevention.

Crime

Crime rates in residential areas affect the health of residents by initiating a fear response and increase in stress, which subsequently decreases physical activity levels. Studies have shown correlations between rates of crime and preterm birth (Messer et al. 2006), and fear of crime and poor mental health and limited physical functioning, physical activity, and social behavior (Stafford et al. 2007).

Objectives

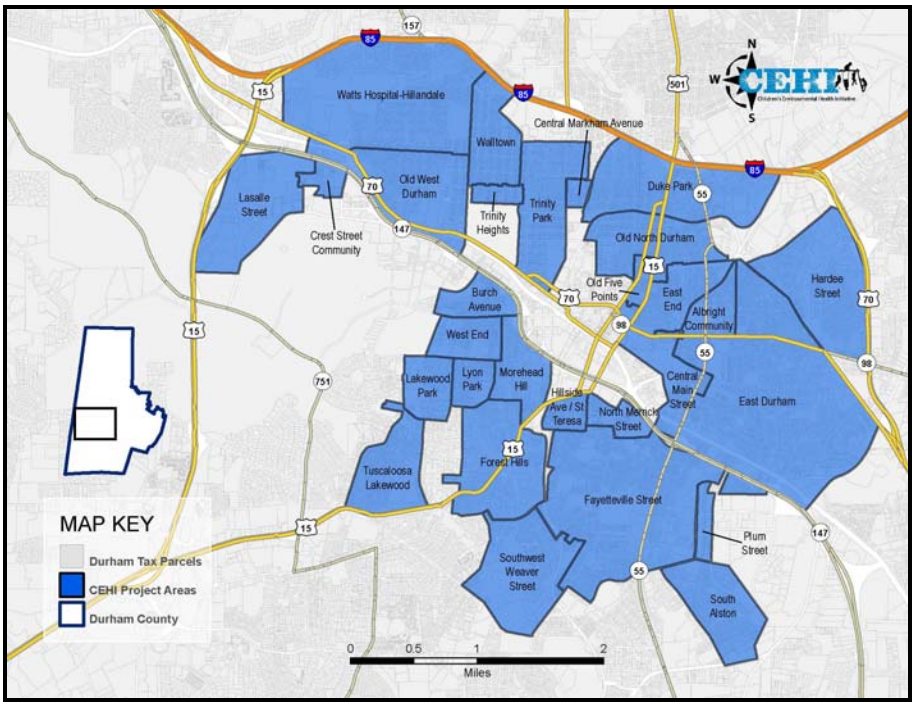
The built environment is spatially variable, affecting neighborhoods within geographic proximity in contrasting ways. Motivated by pronounced health disparities in Durham and interest on both the part of community members and Duke University, this study aims to better understand the impact of the built environment on health outcomes. This Community Assessment Project (CAP) captures the variability in neighborhood health for Central Durham, North Carolina using approximately 60 built environment variables. The goal of this study is six-fold: (1) to build GPS-enabled technology for the systematic measurement of elements of the built environment, (2) to design and implement a field data collection protocol, (3) to build an integrated GIS of all data, (4) to construct summary indices of built environment data, (5) to disseminate study results to community stakeholders, and (6) to develop a best practices recommendation for assessing the built environment.

This project was undertaken as part of the environmental health portfolio of the Children's Environmental Health Initiative (CEHI). CEHI is a research, education, and outreach program committed to fostering environments where all children can prosper. CEHI staff designed a technological application for assessing the built environment launched off handheld GPS units to assess Central Durham neighborhoods. The database provides critical information to city officials, researchers, and communities, but also serves as the substrate for constructing an index for summarizing the multiple components of the built environment. A neighborhood health index (NHI) is an intermediate step in the analysis of the relationship between the built environment, public health, and clinical data.

Methods

Data Collection

The community assessment encompasses 22 of Central Durham's neighborhoods with 7 extension neighborhoods added in order to capture a larger portion of residential areas within Durham's "urban core". **Map 1** shows the total project area and the neighborhoods included.



Map 1: Neighborhoods included in the Community Assessment Project.

Neighborhood outlines used for the project area are based on boundaries that were provided to CEHI by the Durham Department of Geographic Information Systems. In some cases, CEHI modified these outlines to either expand the area covered by the 22 neighborhoods or create the extension neighborhoods. The project area is characterized by a mosaic of racial groups and socioeconomic classes. As health outcomes tend to vary by race and socioeconomic status, analysis of this area's built environment is hypothesized to be crucial to understanding the health disparities observed in Central Durham.

A community assessment pilot project was conducted from 2007 – 2008 using a list of variables believed to capture all built environment descriptors. After the pilot study, the list of variables was revised to provide an improved database. The final list of variables is provided in **Table 1**. The data collected on these variables creates a comprehensive inventory of the built environment.

Table 1: Community Assessment Project Variable List

Property Descriptors

Property Type	**Commercial Type**	**Community Type**	**Empty Lot Type**
Residential	Business Office	Alcohol and Drug Treatment Center	Residential
Commercial	Child Care Center	Cemetery	Commercial
Community	Medical Office	Community Recreation/Cultural Center	**Residential/Commercial Type**
Government	Dental Office	Hospital	Day Care
Faith	Industrial Building	Military Service Club	Hair Salon/Barber Shop
Empty Lot	Restaurant, Family	Park or Playground	Other
Residential/Commercial	Restaurant, Drive-Up	Public Health Care/Clinic	**Parking Lot Type**
Other Mix Type	Hair Salon/Barber Shop	School K-12	Residential
Property Status	Auto Repair Shop	School-University	Commercial
Occupied	Bar/Club	Other	Community
Unoccupied	Liquor Store	**Government Type**	Government
Demolished	Adult Merchandise	Fire Station	Faith
Residential Type	Grocery Store	Government Office	Empty Lot
Single Family	Gas/Convenience	Correctional Facility	Residential/Commercial
Apartment Complex (3-6)	Pawn Shop	Library	Other
Apartment Complex (more than 6)	Gun Shop	Museum/Cultural Center	
Duplex	Private Gym	Police Station	
Care Facility	Law Office	US Post Office	
Senior Housing	Bail Bond	Other	
Multi-Address Home	Utility/Gas/Electric Plant	**Faith Type**	
Mobile Home	Day Laborer Office	Church	
Other	Check-Cashing/Money Lending Service	Mosque	
	Tienda	Synagogue	
	Other	Temple	

	Vacant	Other	

Variables

Broken Windows	Fencing	**Nuisances**	Data Collector
Boarded Door	Fence Damage	Standing Water	Date
Holes in Walls	Fence Material	Litter	
Roof Damage	Fence Area	Garbage	
Residential Chimney Damage	Security Bars	Broken Glass	
Foundation Damage	Barbed Wire	Discarded Furniture	
Residential Front Entry Type	No Trespassing Sign	Discarded Appliances	
Residential Front Entry Damage	Beware of Dog Sign	Discarded Tires	
Peeling Paint	Security Sign	Inoperable Vehicle	
Peeling Paint Area	For Sale Sign	High Weeds/Grass	
Fire Damage	For Rent Sign	Graffiti	
Condemned	Other Sign	Other Nuisance	
Eviction Notice	Dog		
Padlocked	Window AC Unit		
Residential Driveway	Home Repair		
Residential Cars on Lawn	New Home Construction		
Residential Garden	Comments		
Residential Greenery			
Residential No Grass			

The variables included in the database were all carefully chosen to produce a comprehensive inventory useful for referencing in the future. While the property descriptors are text fields categorizing the properties, nearly all of the variables are binary data with values of 0 and 1 corresponding to "No" and "Yes" to indicate their presence. Binary variables, in contrast to ranges of values quantifying the magnitude of variables, were chosen to improve the objectivity of the data. All property descriptors with text fields have default fields of "Null", while binary variables have a default value of "0", thus, the variable only needed to be edited in the event that it was observed.

At the core of the built environment project is an Access database that contains fields for each of the variables listed in **Table 1**. These fields are linked to the approximately 18,000 tax parcels included in the neighborhood assessment by assigning each parcel a unique ID. The built environment database stores information in three feature classes: parcel centroids, nuisance points, and sidewalks. Each tax parcel contains a centroid, a point feature class that allows the parcel to be described by the presence or absence of the built environment variables. Nuisance points document objects that are considered public eyesores or hazards in the public right-of-way. The sidewalks feature class allows the field team to create sidewalks within the database by drawing them on the map using polylines.

Tax parcel data were edited by a field team consisting of six members, four of whom were hand selected from applicants to the DukeEngage internship program at Duke University. The fifth was a high school student from Josephine Dobbs Clement Early College High School. The entire field team trained on ArcGIS (via ESRI's virtual campus at http://training.esri.com), ArcPad, and the use of the GPS units. Field team members also completed detailed training on

the database, variable definitions, and proper assessment techniques in order to ensure inter-rater reliability. Furthermore, each field team member received his or her IRB certification by completing required modules (https://researchethics.duhs.duke.edu/).

Data collection took place from June 2008 – August 2008 between the hours of 7am and 1pm, Monday through Friday. Tools used for data collection were six Trimble GeoExplorer 2005 Series GPS units using an ArcPad platform to enable the database for GPS. A copy of the database was "checked-out" from Arc for each individual field team member, transferred to the GPS units, and "checked-in" to the database every 1-2 days in order to update the database after data collection. Data check-in was always performed by the project manager.

Assessment of parcels began with the observation of the parcel from all perspectives and angles possible by remaining on the sidewalk or on the street. At no time during assessment did data collectors trespass onto private property. To record data, the centroid was opened and the data collector recorded the absence or presence of each variable contained within the database by selecting from drop-down menus spanning multiple pages. Parcels were displayed as polygons in the database. Thus, each parcel adjacent to the road has at least one line segment demarcating the property boundary from public space and roads. Most parcels had neighboring parcels on three sides, meaning that only one line segment was next to the road. Other parcels that were located on street corners possessed two line segments adjacent to the street. Each segment of a parcel that was adjacent to the street or public space was observed for the presence of public nuisances such as litter, cigarette butts or boxes, broken glass, and alcohol containers. The data collector drew a point at the midpoint of those segments adjacent to public space and recorded the presence of nuisance variables listed in the

drop-down menu. Sidewalks were traced by drawing a series of vertices. To begin a sidewalk, the data collector stood at the beginning of that segment of sidewalk and then took subsequent points as necessary to create a number of vertices sufficient to allow the line connecting those vertices to follow any bend in the sidewalk. Each segment of sidewalk was denoted as being either broken or unbroken and obstructed or unobstructed. Data management, occurring during and post-data collection, involved ensuring the data collector field was filled in for all data, entering the date of data collection, and checking the data for overlooked or twice-assessed parcels, nuisance points, and sidewalks.

Neighborhood Health Index

The built environment variables included in the database naturally form six categories: housing damage, property characteristics, security measures, amenities, vacancy, and nuisances (See **Table 2** in the **Appendix**). In addition to the data collected, tenure status data and crime data were obtained from the Durham County Tax Assessor's Office and the Durham Police Department, respectively, and integrated into the database. Within ArcGIS, each parcel was given a field for each of the categories, with the exception of nuisances. The value for each field was determined by the sum of the observed variables defining that field. Parcel-level data were then spatially joined to and aggregated at the block level, thus, each Census block retained unique identifiers and adopted all fields previously associated with the parcels as the sum of observations within that block.

The variables that make up the amenities category are not binary, but rather nominal descriptions of the property type. Thus, all parcels that are community resources were given a

value of “1” to enable summation at the block level. In addition, data encoding tenure status were manipulated in order to allow interpretation of results. Tenure status of all residential-use parcels is defined as either owner-occupied or renter-occupied. For this reason, summaries calculated using dichotomous notation would have eliminated the possibility of determining whether blocks were mostly owner or renter-occupied. Thus, owner-occupied parcels were given a value of “1” and renter-occupied parcels a value of “-1”. In this way, positive values in the tenure field denote greater percentages of owner-occupied housing at the block level, while negative values correspond to greater percentages of renter-occupied housing.

While aggregation at the block level provides a general idea of the conditions of the built environment, analysis of individual blocks may not reflect the conditions of the community or neighborhood in which residents are engaged. Thus, to extend understanding of the neighborhood context, blocks were assigned new scores for each index, calculated as a summation of the scores of 1) primarily adjacent blocks and 2) secondarily adjacent blocks. Depicted in **Figure 1,** this level of neighborhood resolution allows analysis at multiple scales. An Arc-based model calculated the indices based on the user-defined conditions of primary and secondary adjacency.

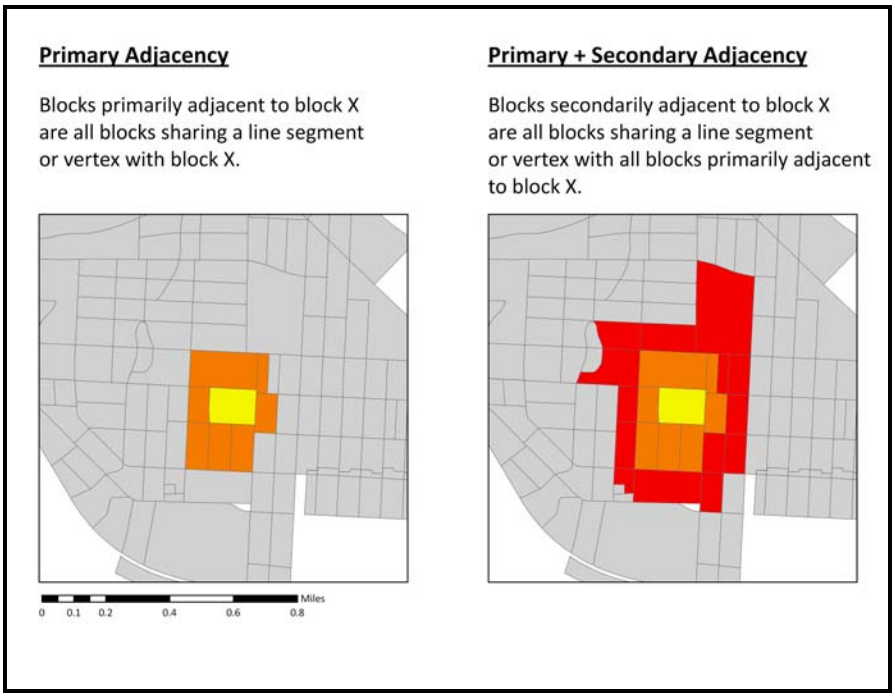


Figure 1: The concepts of primary and secondary adjacency used to perform analysis of all built environment data.

Using **equation 1** below (where X is each score for each index, μ is the mean value for each index, and σ is the standard deviation for each index), the Z-scores were calculated from the raw counts to standardize the indices in a way that facilitated cross-indices comparisons and converted highly variable scores into more easily interpretable ranges.

$$Z = (X - \mu) / \sigma \qquad \textbf{(equation 1)}$$

These indices were then aggregated at the CEHI project area level and the summary statistics calculated for each neighborhood.

Results

Spatial Analysis

The US Census Bureau defines areal units such as blocks, block groups, tracts, and zip codes to conduct surveys and report data. Census blocks are the smallest of these units and

roughly correspond to city blocks. Data collection occurred at the tax parcel level in order to obtain information at the finest resolution possible; however, results are tabulated, analyzed, and mapped at the Census block level in order explore the impact of the built environment on health within a neighborhood context.

Analysis is facilitated by examination of the summary statistics for each of the indices. **Table 3** provides the summary statistics for the pre-standardized indices, while **Histograms 1 – 24** (see **Appendix**) show the frequency of the scores for each index, pre-standardization.

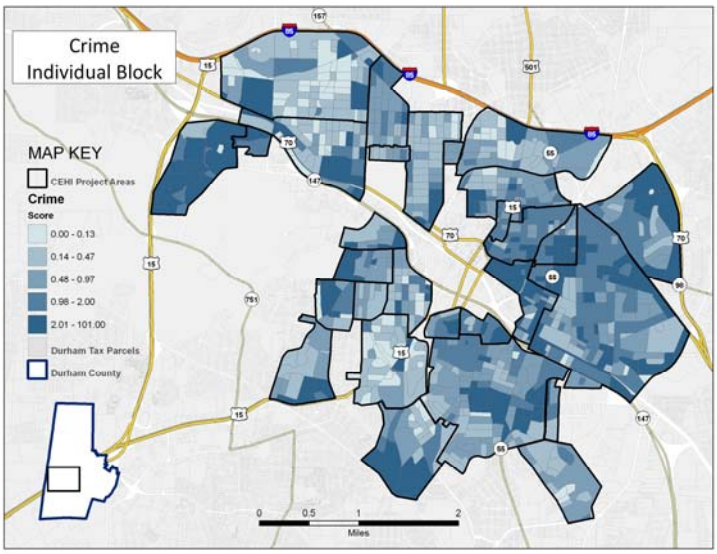
	Mean	Min	Max	Standard Deviation
Individual Blocks				
Housing Damage	5.127896	0	75	7.083793
Property Damage	10.19463	0	142	14.12854
Security Measures	5.62836	0	85	6.901933
Tenure Status	0.343837	-50	87	7.881386
Vacancy	2.412419	0	41	3.87854
Crime	17.20482	0	379	29.02378
Amenities	0.310473	0	8	0.80469
Nuisances	29.33735	0	308	33.51897
Primary Adjacency				
Housing Damage	44.01668	0	272	39.29355
Property Damage	88.56256	0	627	79.62754
Security Measures	48.65616	0	324	36.39931
Tenure Status	2.944393	-176	202	40.97929
Vacancy	20.92956	0	132	18.80214
Crime	153.7303	0	1162	139.8781
Amenities	2.782206	0	16	2.784476
Nuisances	252.2437	0	1432	195.5726
Secondary Adjacency				
Housing Damage	133.0871	0	521	97.49073

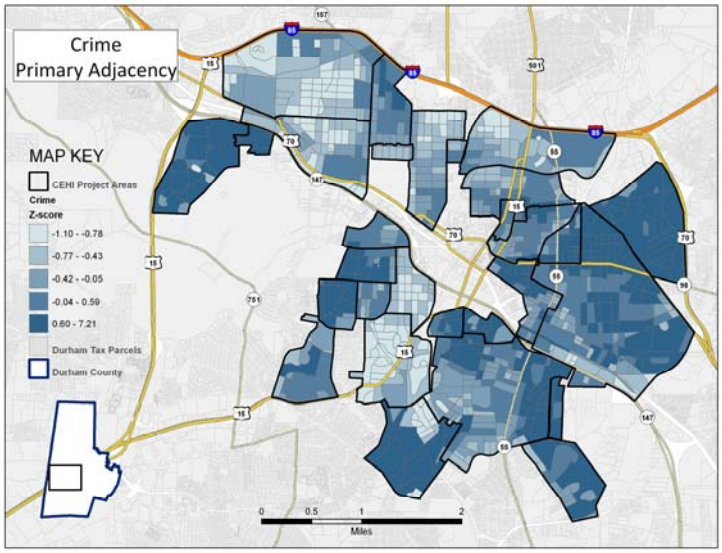
Table 3: Summary statistics of the raw data for the neighborhood health indices (NHI), at all three analysis scales.

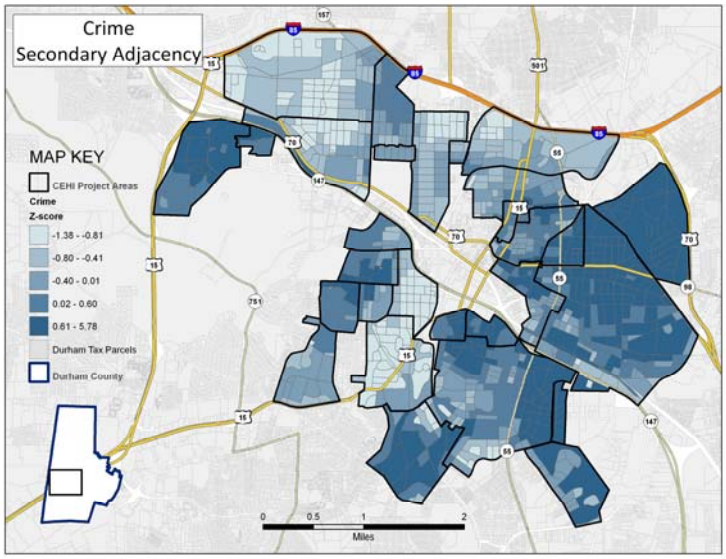
Property Damage	266.7229	0	1208	197.8052
Security Measures	147.1205	0	476	84.64608
Tenure Status	6.624652	-238	295	96.77665
Vacancy	62.87118	0	248	62.87118
Crime	444.8656	14	2253	312.5381
Amenities	8.025023	0	25	5.055423
Nuisances	760.3689	16	2835	487.9528

Histograms for the indices using the Z-scores have distributions identical to the pre-standardized indices. A table showing the summary statistics for the indices using the Z-scores is not included, as the table does not provide any useful information. Data in **Table 3** shows the mean values and the large standard deviations, which indicate the variability observed in the project area.

The NHI was mapped using the Z-scores within the project area at the Census block level and maps of the indices' spatial variation are included in the **Appendix**. **Maps 2 – 9** display the eight indices at the individual block level, **Maps 10 – 17** display the indices at the primary adjacency level, and **Maps 18 – 25** correspond to secondary adjacency. Maps of crime rates are shown below to demonstrate the pattern of spatial distribution of the indices. At the individual block level there is a high degree of index variability between adjacent blocks, creating a mosaic pattern. Subsequently, as you look at the next map depicting the distribution of the NHI at the primary adjacency scale, it becomes more homogenous with a clustering effect. At the secondary adjacency scale, there is a further increase in homogeneity, which roughly corresponds to neighborhood boundaries. This indicates that the spatial scale used to define "neighborhood" impacts the local measure of the built environment.


Crime
Individual Block
MAP KEY
CEHI Project Areas
Crime
Score
0.00 - 0.13
0.14 - 0.47
0.48 - 0.97
0.98 - 2.00
2.01 - 101.00
Durham Tax Parcels
Durham County
0 0.5 1 2
Miles


Crime
Primary Adjacency
MAP KEY
CEHI Project Areas
Crime
Z-score
-1.10 - -0.78
-0.77 - -0.43
-0.42 - -0.05
-0.04 - 0.59
0.60 - 7.21
Durham Tax Parcels
Durham County
0 0.5 1 2
Miles


Crime
Secondary Adjacency
MAP KEY
CEHI Project Areas
Crime
Z-score
-1.38 - -0.81
-0.80 - -0.41
-0.40 - 0.01
0.02 - 0.60
0.61 - 5.78
Durham Tax Parcels
Durham County
0 0.5 1 2
Miles

Housing damage, property damage, vacant lots, nuisances, and crime occur in the typical mosaic theme when mapped at the individual block level; however, there are increased concentrations of each of these indices within specific neighborhoods—East Durham, Albright Community, East End, Burch Avenue, West End, Merrick Street, Hillside Avenue/St. Teresa, and Fayetteville Street. In contrast, that mosaic pattern is eliminated by moving to larger scale analysis at the primary and secondary adjacency and the clustering of these indices within the aforementioned neighborhoods is enhanced when compared to other neighborhoods.

Similarly reflecting the relationship revealed by the correlation analysis is the spatial distribution of amenities. The distribution of amenities throughout the study area does not seem to follow any pattern. Instead of seeing clusters of amenities or community resources located in areas of medium or high income, there appear to be clusters in areas that are high minority or of low socioeconomic status. However, this is likely due to the variables comprising the amenities category and the low number of observations of these variables throughout the project area. The maximum number of amenities observed at the block level was 8, 16 at the primary adjacency level, and 25 at the secondary adjacency level. This small *n* makes interpretation of the index difficult. When amenities are mapped at the secondary adjacency level, low scores among blocks is due to edge effects and the central location of those blocks within residential areas, thus isolating them from community resources.

The spatial distribution of tenure status is the complete opposite of the five positively correlated indices, which is to be expected given the fact that tenure is negatively associated with them. Finally, the spatial distribution of security measures exhibits a strong mosaic

throughout all of the project area neighborhoods except in Old West Durham and Watts Hospital-Hillandale neighborhoods.

Correlation Analysis

To explore the associations among indices and between indices and demographic variables obtained from Census 2000 data, I calculated Pearson's Correlation Coefficients. The strength and direction of these associations will likely prove valuable in future research relating the NHI to health outcomes. The largest scale at which the NHI measures characteristics of the built environment is the individual block level. At this scale, each block's respective score is determined solely by the number of observations of variables within that block. Characteristics of adjacent blocks are not included. The correlation coefficients (r) between indices for individual blocks are given in **Table 4** in the **Appendix**; p-values are less than 0.001 unless otherwise noted. Housing damage has a strong, positive association with property damage (r = 0.85), security (r = 0.68), vacancy (r = 0.65), and nuisances (r = 0.81). It has a weak, positive association with crime and amenities (r= 0.39 and r = 0.23, respectively) and a negative association with tenure status (r = -0.24). Housing damage also has a weak, positive association with percent black (r = 0.28), percent Hispanic (r = 0. 17), percent minority (r = 0.30), percent on public assistance (r = 0.26), percent in poverty (r = 0.24), and percent children under five in poverty (r = 0.23). It is also weakly and negatively associated with household median income (r = -0.23).

Property damage is strongly and positively associated with security (r = 0.72), vacancy (r = 0.70), and nuisances (r = 0.87). It also has a moderate and positive association with crime (r =

0.47). As with housing damage, property has a negative correlation with tenure status (r = -0.23), a weak and positive association with amenities (r = 0.22), percent black (r = 0.29), percent Hispanic (r = 0.21), percent minority (r = 0.32), percent on public assistance (r = 0.26), percent in poverty (r = 0.26), and percent children under five in poverty (r = 0.22), and a negative association with household median income (r = -0.23).

Security has a strong and positive association with both vacancy (r = 0.52) and nuisances (r = 0.70). While it has positive associations with percent black (r = 0.20), percent minority (r = 0.19), percent on public assistance (r = 0.14), and percent children under five in poverty (r = 0.08, p = 0.007), they are weak associations.

Tenure has a weak and negative association with vacancy (r = -0.21), nuisances (r = -0.28), crime (r = -0.17), percent black (r = -0.27), percent Hispanic (r = -0.23), percent minority (r = -0.32), percent on public assistance (r = -0.27), percent in poverty (r = -0.35), and percent children under five in poverty (r = 0.30). It is positively associated with household median income (r = 0.36).

Vacancy has a strong, positive association with nuisances (r = 0.70). It has a weaker, yet positive association with crime (r = 0.36), amenities (r = 0.18), percent black (r = 0.25), percent Hispanic (r = 0.16), percent minority (r = 0.26), percent on public assistance (r = 0.28), percent children under five in poverty (r = 0.23), and percent in poverty (r = 0.18). It is negatively associated with household median income (r = -0.22).

Nuisances have a strong positive association with crime (r = 0.54) and weaker association with amenities (r = 0.30), percent black (r = 0.30), percent Hispanic (r = 0.21), percent minority (r = 0.33), percent on public assistance (r = 0.29), percent in poverty (r = 0.27),

and percent children under five in poverty (r = 0.22). It is negatively associated with household median income (r = -0.25).

Crime is weakly associated with amenities (r = 0.20), percent black (r = 0.19), percent Hispanic (r = 0.19), percent minority (r = 0.23), percent on public assistance (r = 0.23), percent children under five in poverty (r = 0.21), and percent in poverty (r = 0.14). It is negatively associated with household median income (r = -0.17).

Amenities is not associated with any of the demographic categories. Other associations are mentioned in the above paragraphs.

The next scale at which the NHI describes the built environment is primary adjacency. In this method, blocks are assigned scores that are summations of their own within-block scores and the scores of all primarily adjacent blocks. The correlations between primary adjacency indices and demographic data (**Table 5**) are similar to those of the individual blocks, but they are more robust associations. This suggests the validity of the methods for analysis and the importance of neighborhood context when considering the indices. Housing damage is correlated with property damage (r = 0.913), security measures (r = 0.745), vacant lots (r = 0.763), and nuisances (r = 0.917). Property damage is correlated with security measures (r = 0.771), vacant lots (r = 0.775), nuisances (r = 0.942), and crime (r = 0.611). Security is correlated to vacant lots (r = 0.572) and nuisances (r = 0.746). Tenure status is correlated only to household median income (r = 0.547). Vacant lots is correlated solely to nuisances (r = 0.807) and nuisances is correlated to crime (r = 0.658) and percent minority (r = 0.520). Amenities is not correlated to any of the indices or demographic variables.

The third scale at which the NHI describes the built environment is secondary adjacency. Secondary adjacency assigns blocks scores based on a blocks own score, the scores of all primarily adjacent blocks, and all of the blocks adjacent to those blocks. Correlations between secondarily adjacent blocks and demographic variables are provided in **Table 6**. As was observed with the correlation coefficients for the primary adjacency indices, most of the associations between the secondary adjacency indices and demographic variables are stronger. The greater spatial extent of the secondary adjacency indices also results in a greater number of correlations. House damage was associated with property damage (r = 0.935), security measures (r = 0.760), vacant lots (r = 0.838), and nuisances (r = 0.951). Correlations that were not present at smaller spatial scales include tenure status (r = -0.554), crime (r = 0.670), and amenities (r = 0.559). Property is associated with security (r = 0.773), vacant lots (r = 0.821), nuisances (r = 0.960), crime (r = 0.778), and tenure status (r = -0.554), with tenure status being newly introduced at this scale. Security measures is correlated with vacant lots (r = 0.574), nuisances (r = 0.753), and added at this scale, crime (r = 0.566). Tenure status is negatively associated with nuisances (r = -0.636), positively associated with household median income (r = 0.593), and at this scale only negatively associated with vacant lots (r = -0.633), crime (r = -0.562), and percent children under five in poverty (r = -0.504). Vacant lots are associated with nuisances (r = 0.856), and at this scale crime (r = 0.625), amenities (r = 0.573), and percent on public assistance (r = 0.515). Nuisances are correlated with crime (r = 0.789) and amenities (r = 0.552) at this level.

Multiple Regression Analysis

Much of the current research uses certain demographic variables as indicators or proxies for conditions of the built environment. Statistical analyses were conducted in order to test the hypothesis that demographic data (primarily Census data) are not able to account for the total variance observed within the indices. Resolutions at which demographic data are available vary with the variables measured. Variables used in these analyses that describe Census blocks include median age, percent black, percent Hispanic, percent minority, household median income, percent on public assistance, percentage of children under five in poverty, number of single female-headed households, percentage of single parent family households, average tax value, and median year of house construction. Each of these variables was correlated to each other and to the eight indices describing the built environment at all three analysis scales. In the case of close associations, determined by Pearson's Correlation Coefficient (r), between two demographic variables, I removed one of the variables from the list to avoid over-fitting the model in next-step analyses. Variables removed were percent black and percent Hispanic, as percent black is strongly associated with percent minority.

With the reduced list of demographic variables, I performed multiple regression analysis using demographic variables as predictors of each of the indices. The motivation for this analysis was two-fold: 1) to determine the existence of a best-fit model able to account for a significant percentage of the variance within each of the indices and 2) to determine the efficiency of data collection and the value in the indices resulting from analysis. Two approaches to multiple regression analysis were implemented. In the first, I conducted an "RSQUARE" procedure using SAS. This procedure calculates the r-square value for all model

combinations of *n* predictors. Furthermore, it builds models using 1, 2, … , *n* number of predictors in the model and excludes the intercept from the model. In the second method, I used the simple regression procedure in SAS, which includes the intercept in the model. Comparing the results of these methods allows for the identification and selection of the most appropriate model relating demographic data to the NHI.

I performed regression analysis to determine if there was a best-fit model using the demographic variables as predictors of each of the indices. The best-fit model using the r-square method, which excludes the intercept, accounted for 44.47% of the variance in the secondarily adjacent tenure status index ($R^2 = 0.4447$) using median age, head of household single female, percent minority, household median income, and percent on public assistance as the predictors. No models could account for more than 50% of the variance in the data, and the majority of models accounted for 20 – 30% of the variance. This indicates that the NHI measure aspects of the built environment unaccounted for by demographic data.

The second approach using simple multiple regression produced similar results. This method includes the intercept in the model. The best-fit model using multiple regression was also for the secondarily adjacent tenures status index ($R^2 = 0.4492$) using all of the demographic variables as predictors; however, only median age, head of household single female, percent minority, household median income, and percent on public assistance were statistically significant (H_0: $\beta_{x,i} = 0$). While the R^2—values for multiple regression are slightly higher than for the R-square procedure, the majority of multiple regression models account for 30 – 35% of the total variance observed within the data. In both methods, the primary and secondary adjacency indices display higher R^2–values than the individual blocks and amenities is the least

predictable using demographic variables. The R^2–values for the models predicting the amenities index using the regression method are 0.014, 0.073, and 0.162 for individual blocks, primary adjacency, and secondary adjacency, respectively. Values for the R-square method are 0.014, 0.070, and 0.146 for individual blocks, primary adjacency, and secondary adjacency, respectively.

Discussion

One of the main goals of CAP is to build indices measuring neighborhood health using built environment variables. The data were comprehensive enough to build eight indices that summarize the key components of the built environment. The successful development of these indices was dependent on the collection of data on a parcel-by-parcel level. The utility of this novel method is demonstrated in the scope of the indices and their independence from demographic data.

Inter-Index Correlations

The correlations observed between the indices are not surprising. Housing damage, property damage, security measures, and nuisances all exhibit very strong, positive associations with each other. In addition, they are all negatively associated with tenure status. These trends are present across all three analysis scales, although the strengths of the correlations decrease as the scale becomes more highly resolved. These data show that neighborhoods with lower percentages of owner-occupied housing are more likely to contain properties with damages and nuisances in the public space.

At the secondary adjacency level, tenure status is negatively correlated with house damage, property damage, vacancy, nuisances, and crime. This indicates that the conditions of the built environment decrease as the percentage of renter-occupied housing increases. As mentioned previously, this supports the idea that renters, as compared to owners, may be less likely to be invested in the community or feel less responsible for the maintenance of their property. The resulting decline in the state of the built environment is further correlated with higher crime rates, potentially encouraged by a lack of social cohesion or resident guardianship.

Interestingly, the amenities index displays substantial variability across the analysis scales as well as between indices. It is most strongly correlated with housing damage, vacancy, and nuisances. The association between amenities and vacant properties may be caused by the preference of home-buyers to purchase property situated in neighborhoods with a stable and cohesive community instead of homes that are not located within residential clusters. This theory implies that neighborhoods around commercial or business centers are less stable and would be characterized by higher percentages of renter-occupied properties. Thus, at any given time during data collection, there is more likely to be a greater number of vacant properties in renter-occupied communities than in owner-occupied communities.

Community Assessment Project Report

I designed a 20-page report published for distribution to community members and leaders. The creation of the CAP report is part of the neighborhood dissemination strategy adopted by CEHI and is capable of informing the community of my Phase I summary results, which are of benefit in both community improvement and planning.

The report was printed in a colorful and eye-popping layout and begins with a description of the built environment and a brief discussion of the importance of the built environment in community health. It also includes a background to CEHI's Built Environment project, an explanation of data collection, and six themes—housing characteristics, neighborhood conditions, community resources, food access, neighborhood safety, and demographics—with corresponding maps displaying preliminary results. The maps are paired with explanations of the themes and why they are of interest.

The entire report was written and designed in such a way as to maximize its usefulness to both community members and city leaders. The vision for the report is that it will be a valuable tool in educating the community on conditions of the built environment within their neighborhoods and providing city officials with preliminary results from the study. Furthermore, the report directs all audiences to the CEHI website which contains a page allowing interested parties to print copies of preformatted maps and to explore a mapping-interface featuring the variables included in the assessment.

Utility of the Indices

Current research examining the relationship between the built environment and health outcomes primarily incorporates data at the Census block group or tracts levels. The results of this study indicate that analysis at a more highly resolved scale is necessary to appropriately identify and explore the impacts of the various components of the built environment on human health. This is shown by the degree of variability observed in the spatial distribution of each of

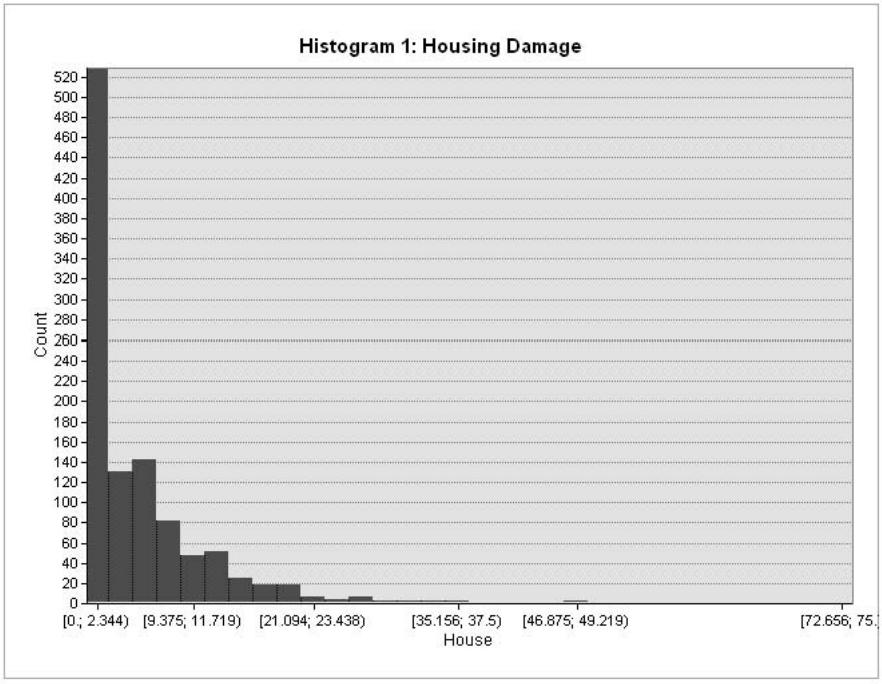
the indices at the block level. Furthermore, the homogenization of the indices at both primary and secondary adjacencies fails to capture this variability.

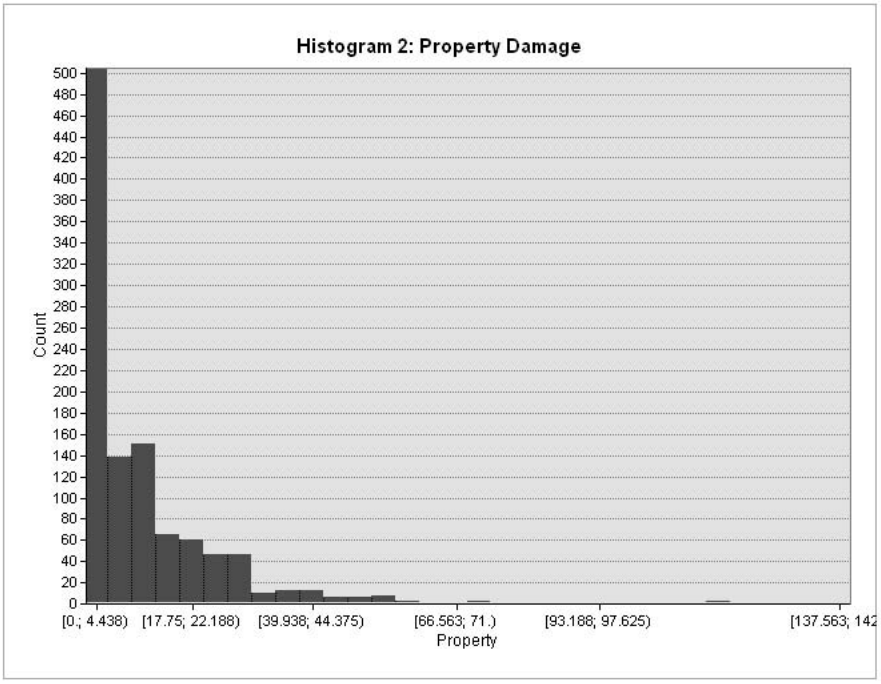
The regression analyses address the independence of the indices. None of the methods employed indicated that demographic variables, when used as predictors of built environment conditions, or the NHI, are able to account for the variation observed within the data. This indicates that the NHI is able to measure aspects of the built environment not accounted for by demographic data. These results indicate the utility of the CAP database and the methods developed to conduct the study. Future research steps include extensive dissemination of the results to community members and city and public health officials and linking the NHI to health outcomes within the project area.

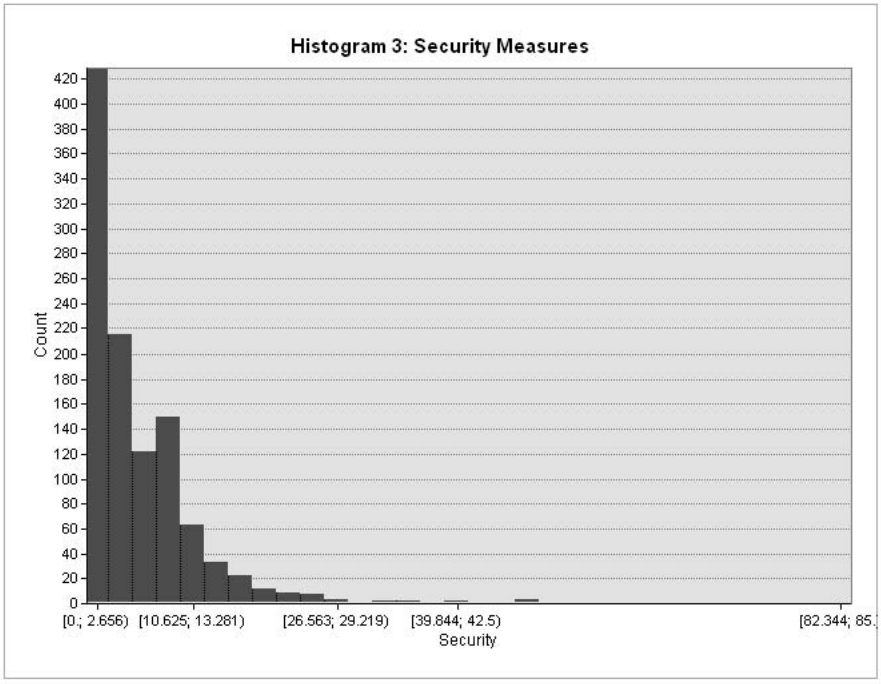
Appendix

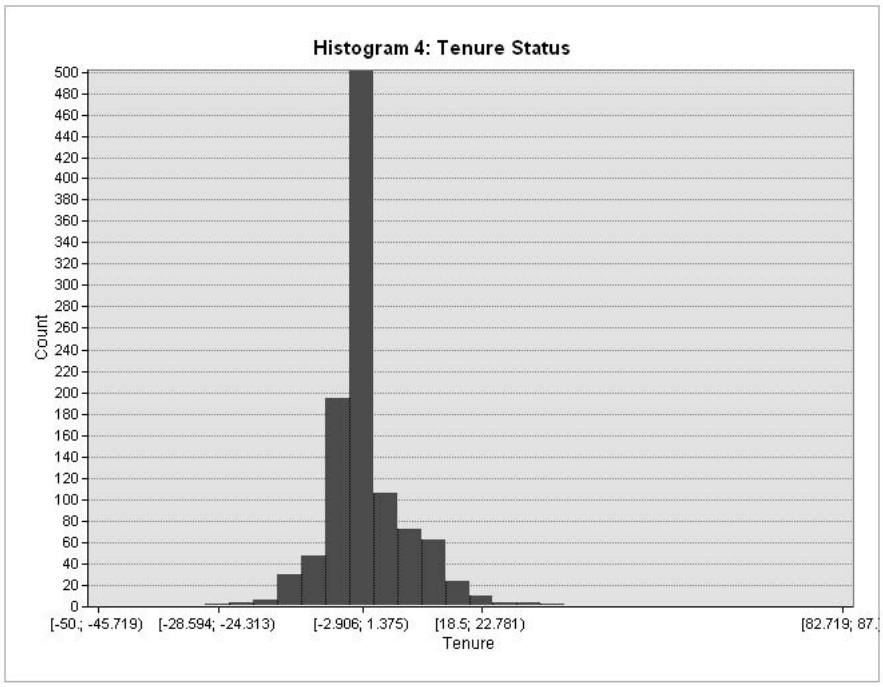
Table 2

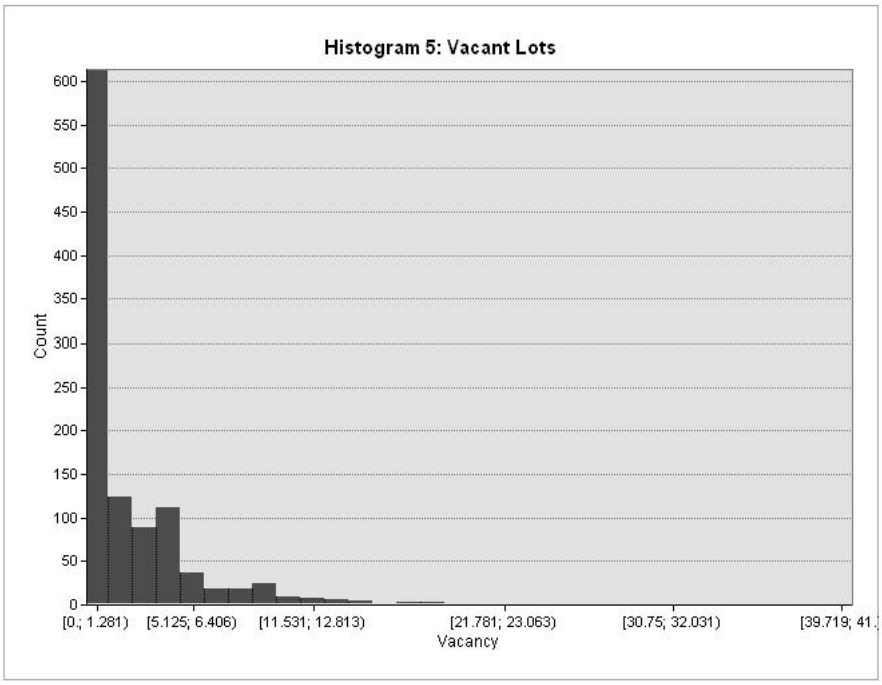
Housing Damage	Property Characteristics	Security Measures	Amenities	Tenure	Vacancy	Nuisances
Broken windows	Cars on lawn	Security bars	Schools	Owner-occupied	Vacant commercial	Standing water
Boarded windows	No grass	Barbed wire	Libraries	Renter-occupied	Vacant residential	Litter
Boarded door	Standing water	No trespassing sign	Faith institutions		Vacant empty lot	Garbage
Holes in walls	Litter	Beware of dog sign	Day care centers			Broken glass
Roof damage	Garbage	Security sign	Health care providers			Discarded furniture
Chimney damage	Broken glass		Grocery stores			Discarded appliances
Foundation damage	Discarded furniture		Parks			Discarded tires
Entry damage	Discarded appliances		Community Centers			Inoperable vehicle
Door damage	Discarded tires					High weed or grass
Peeling paint	Inoperable vehicles					Graffiti
Fire damage	High grass or weeds					
Condemned						

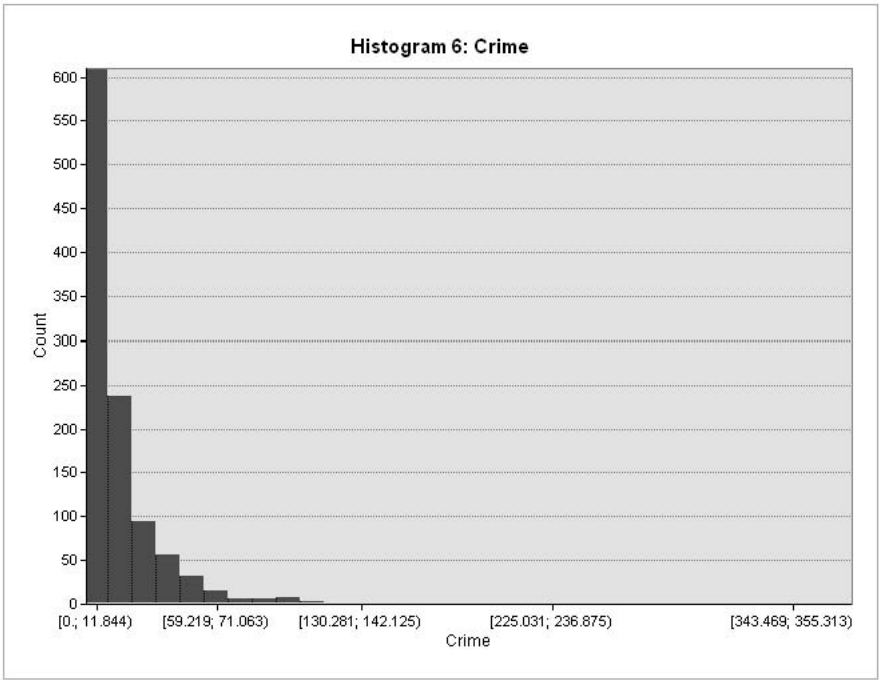

Histogram 1: Housing Damage
Count
House
[0.; 2.344)
[9.375; 11.719)
[21.094; 23.438)
[35.156; 37.5)
[46.875; 49.219)

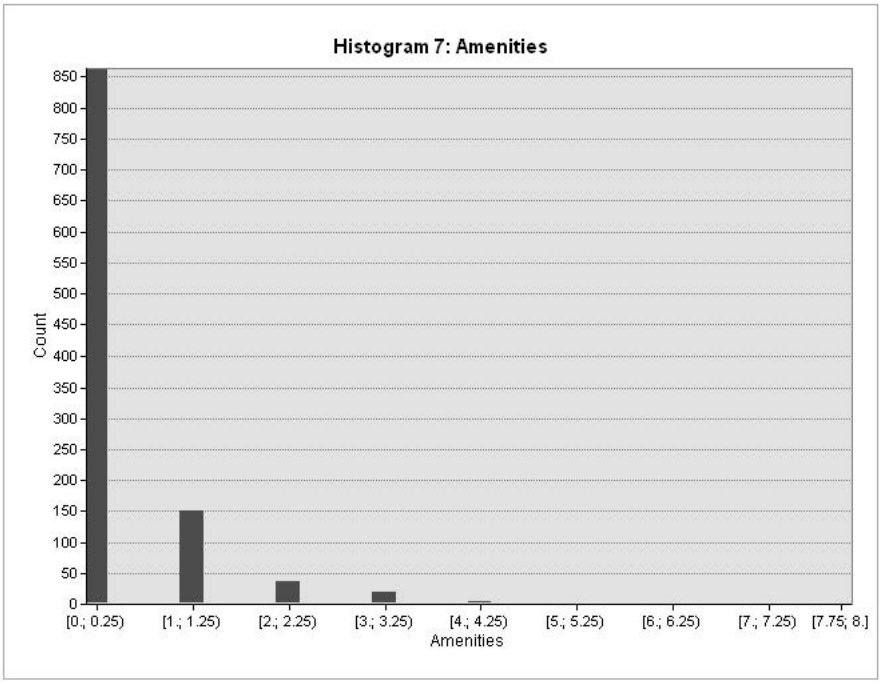

Histogram 2: Property Damage
Count
Property
[0.; 4.438)
[17.75; 22.188)
[39.938; 44.375)
[66.563; 71.)
[93.188; 97.625)
[137.563; 142

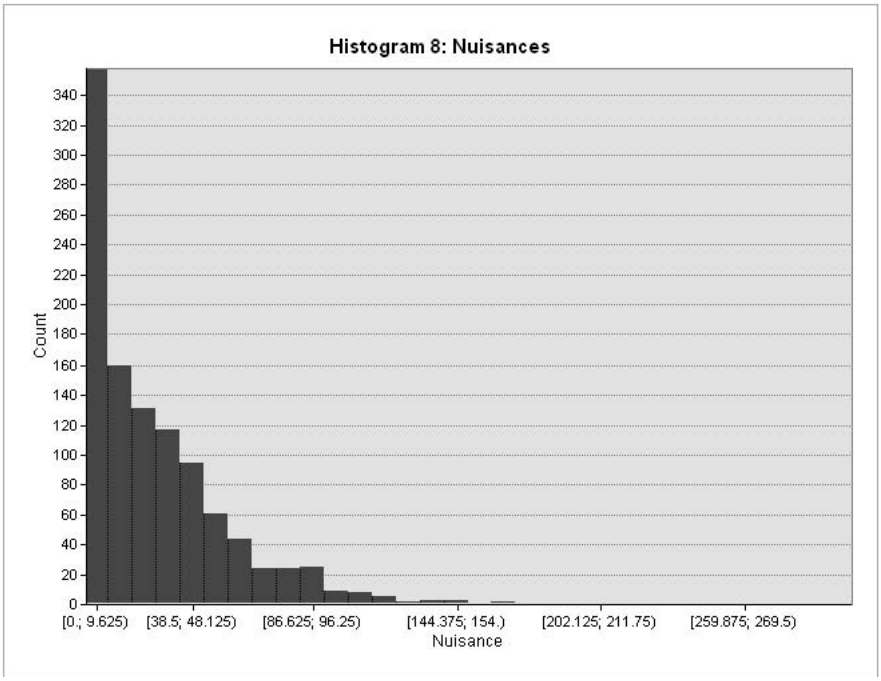

Histogram 3: Security Measures
Count
Security
[0.; 2.656)
[10.625; 13.281)
[26.563; 29.219)
[39.844; 42.5)
[82.344; 85.

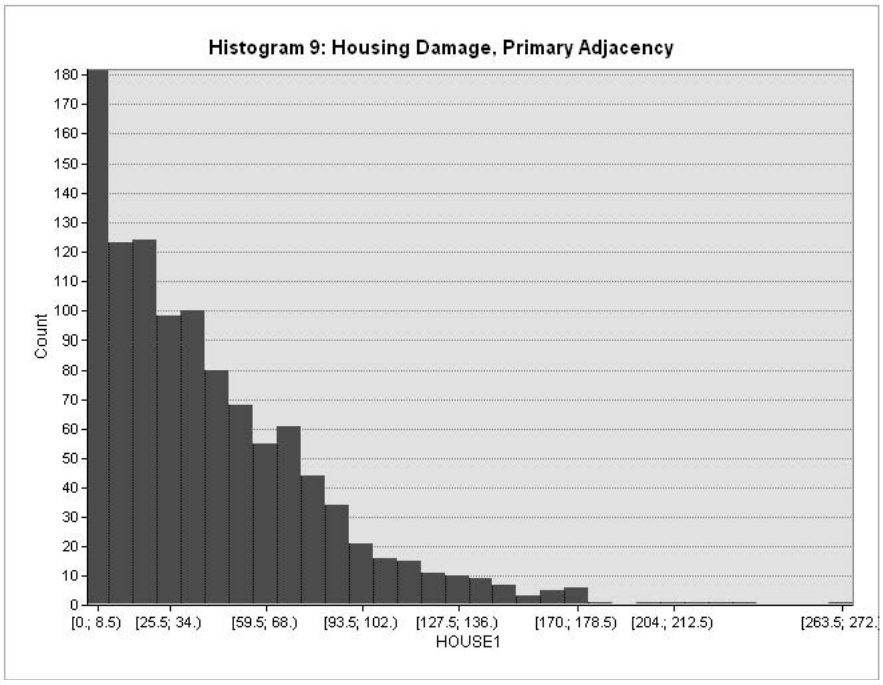

Histogram 4: Tenure Status
Count
Tenure
[-50.; -45.719)
[-28.594; -24.313)
[-2.906; 1.375)
[18.5; 22.781)
[82.719; 87.

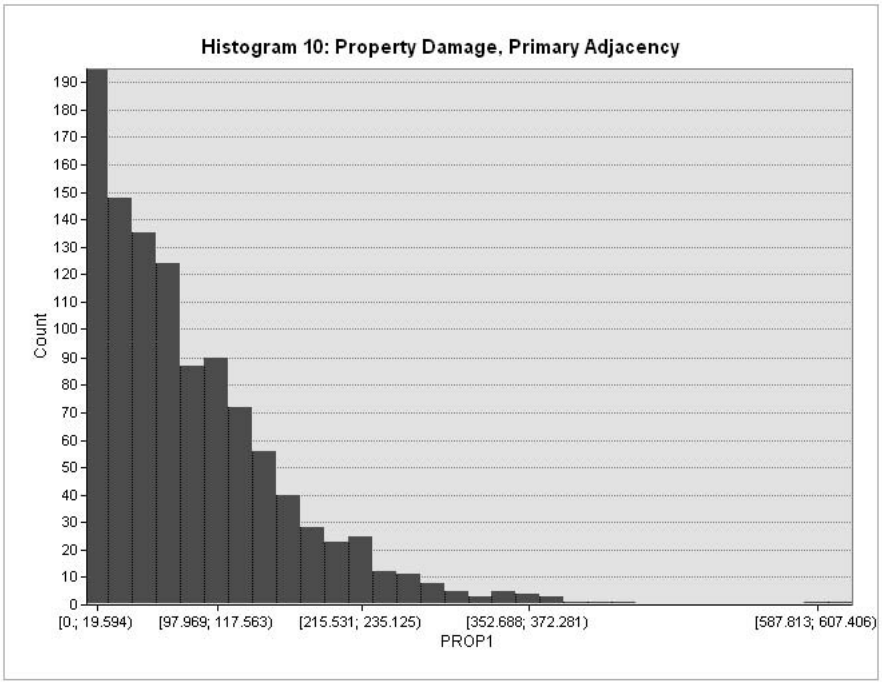

Histogram 5: Vacant Lots
Count
600
550
500
450
400
350
300
250
200
150
100
50
0
[0.; 1.281)
[5.125; 6.406)
[11.531; 12.813)
[21.781; 23.063)
[30.75; 32.031)
[39.719; 41.
Vacancy

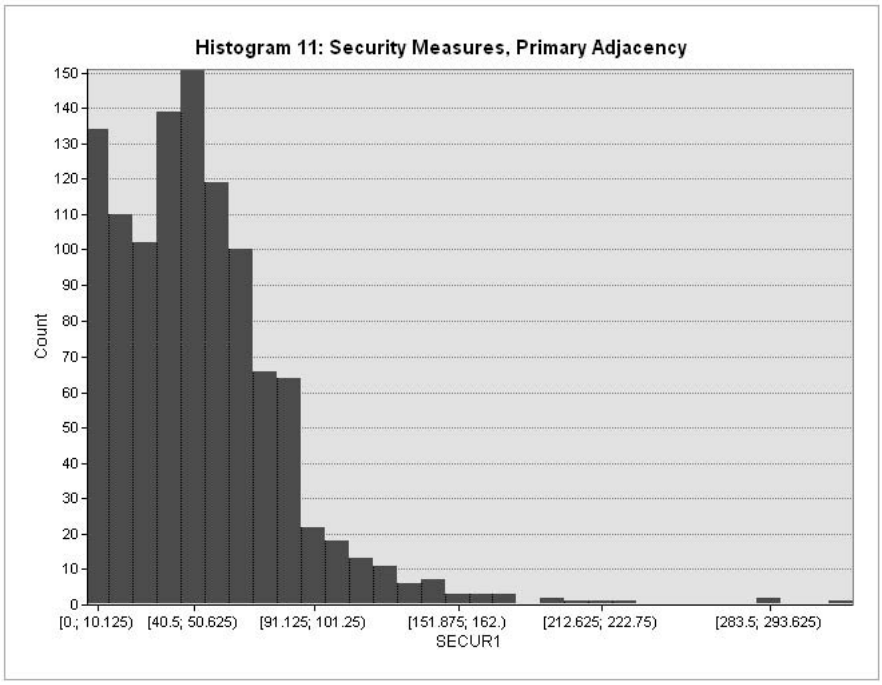

Histogram 6: Crime
Count
600
550
500
450
400
350
300
250
200
150
100
50
0
[0.; 11.844)
[59.219; 71.063)
[130.281; 142.125)
[225.031; 236.875)
[343.469; 355.313)
Crime

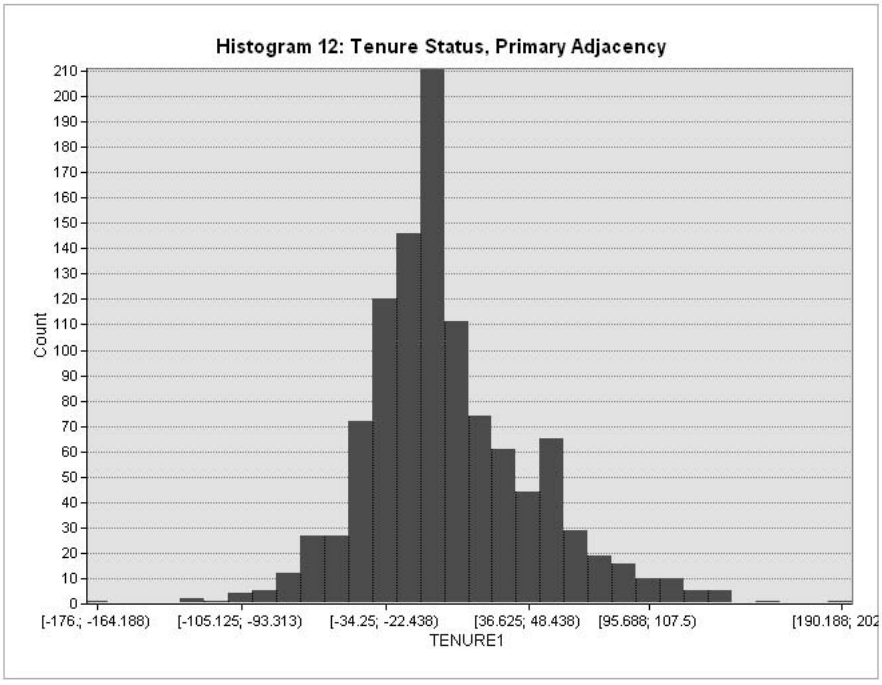

Histogram 7: Amenities
Count
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
[0.; 0.25)
[1.; 1.25)
[2.; 2.25)
[3.; 3.25)
[4.; 4.25)
[5.; 5.25)
[6.; 6.25)
[7.; 7.25)
[7.75; 8.]
Amenities

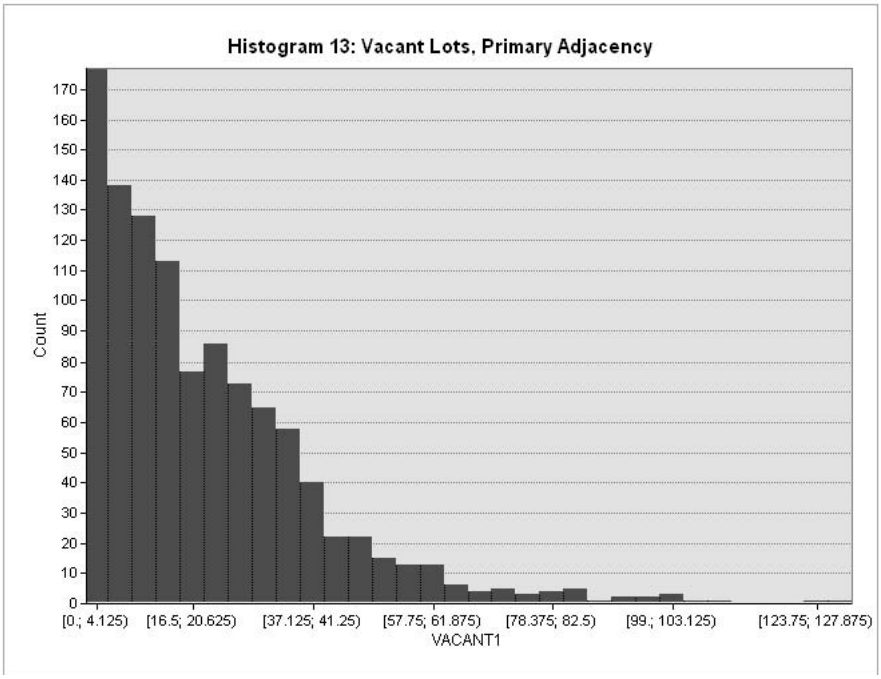

Histogram 8: Nuisances
Count
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
[0.; 9.625)
[38.5; 48.125)
[86.625; 96.25)
[144.375; 154.)
[202.125; 211.75)
[259.875; 269.5)
Nuisance

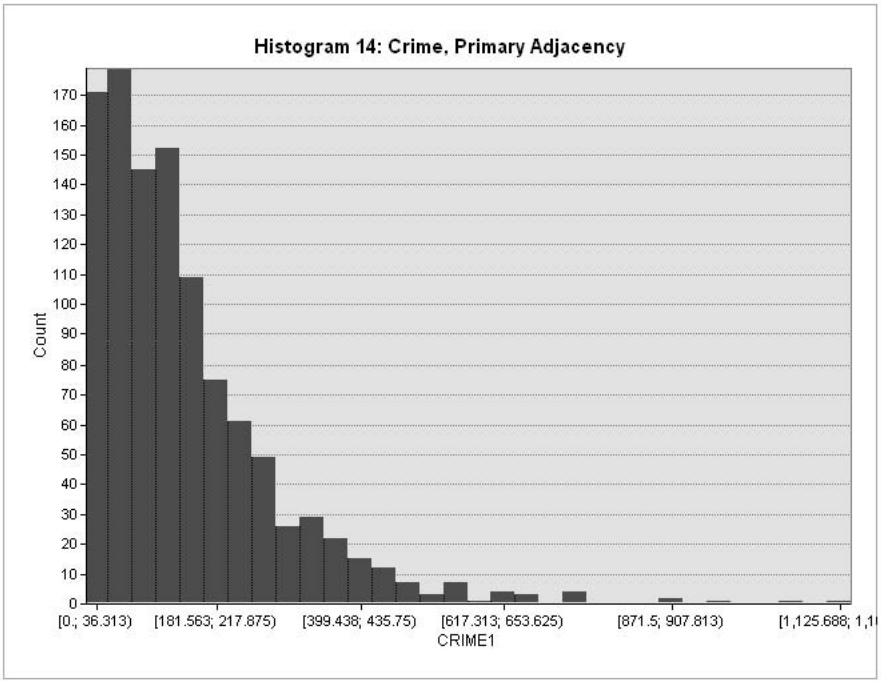

Histogram 9: Housing Damage, Primary Adjacency
Count
HOUSE1
[0.; 8.5)
[25.5; 34.)
[59.5; 68.)
[93.5; 102.)
[127.5; 136.)
[170.; 178.5)
[204.; 212.5)

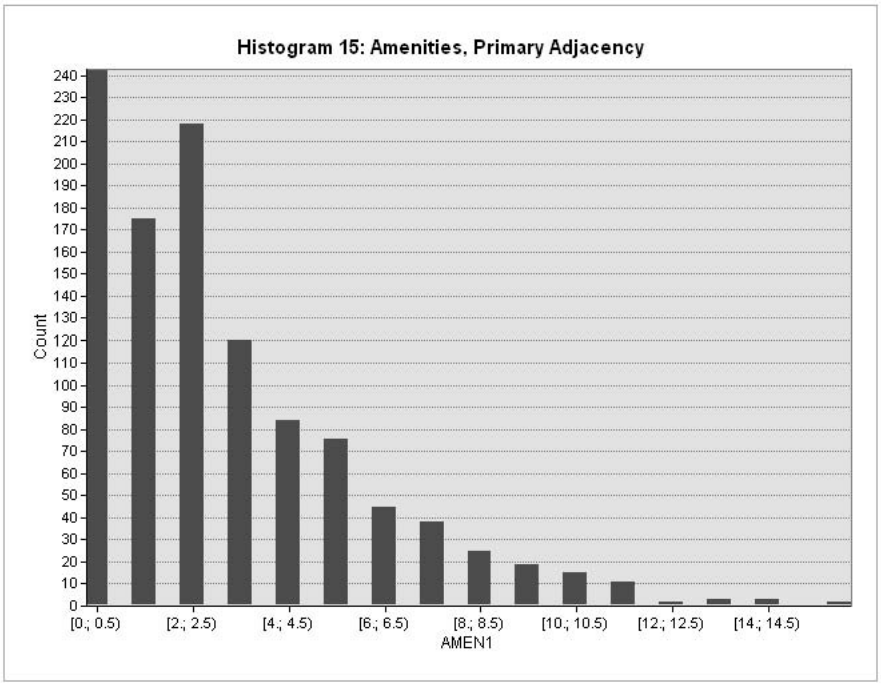

Histogram 10: Property Damage, Primary Adjacency
Count
PROP1
[0.; 19.594)
[97.969; 117.563)
[215.531; 235.125)
[352.688; 372.281)
[587.813; 607.406)

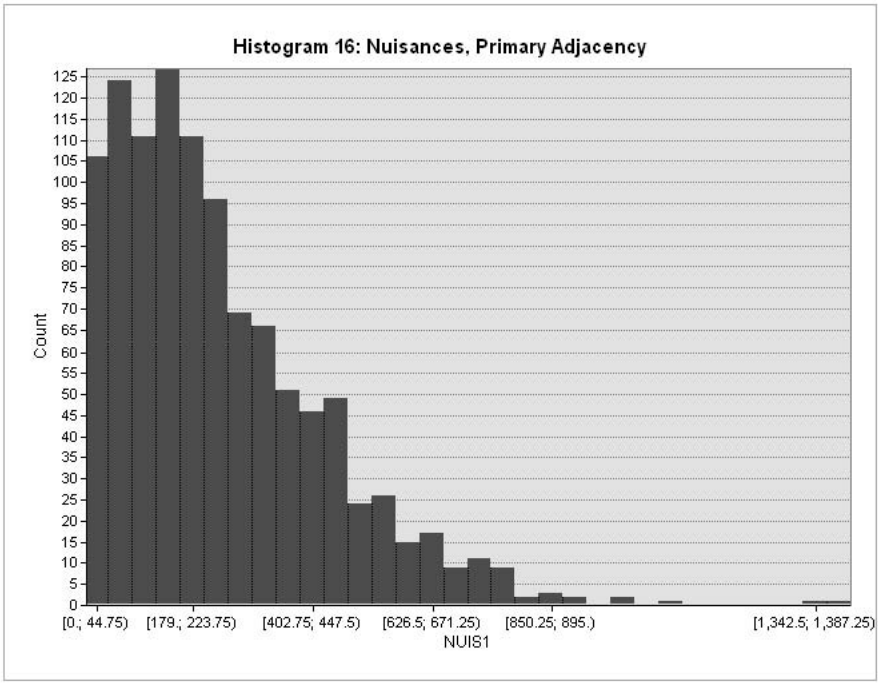

Histogram 11: Security Measures, Primary Adjacency
Count
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
[0.; 10.125)
[40.5; 50.625)
[91.125; 101.25)
[151.875; 162.)
[212.625; 222.75)
[283.5; 293.625)
SECUR1

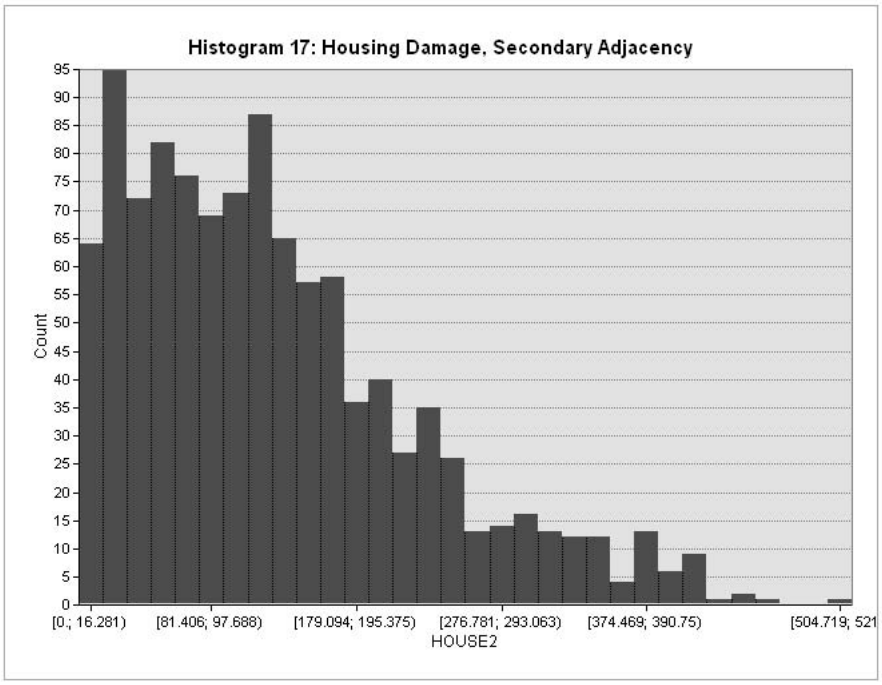

Histogram 12: Tenure Status, Primary Adjacency
Count
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
[-176.; -164.188)
[-105.125; -93.313)
[-34.25; -22.438)
[36.625; 48.438)
[95.688; 107.5)
[190.188; 202
TENURE1

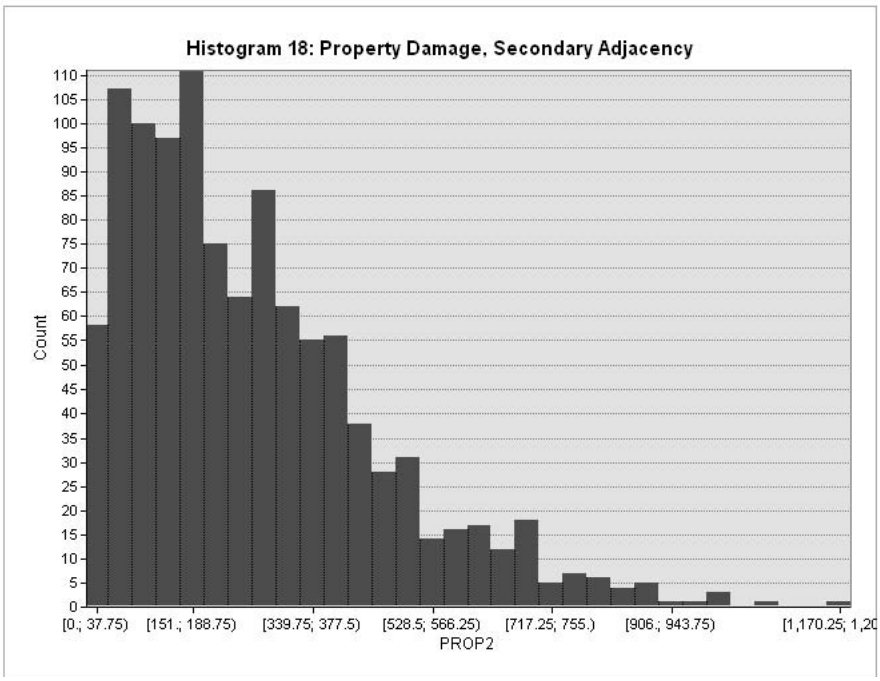

Histogram 13: Vacant Lots, Primary Adjacency
Count
VACANT1
[0.; 4.125)
[16.5; 20.625)
[37.125; 41.25)
[57.75; 61.875)
[78.375; 82.5)
[99.; 103.125)
[123.75; 127.875)

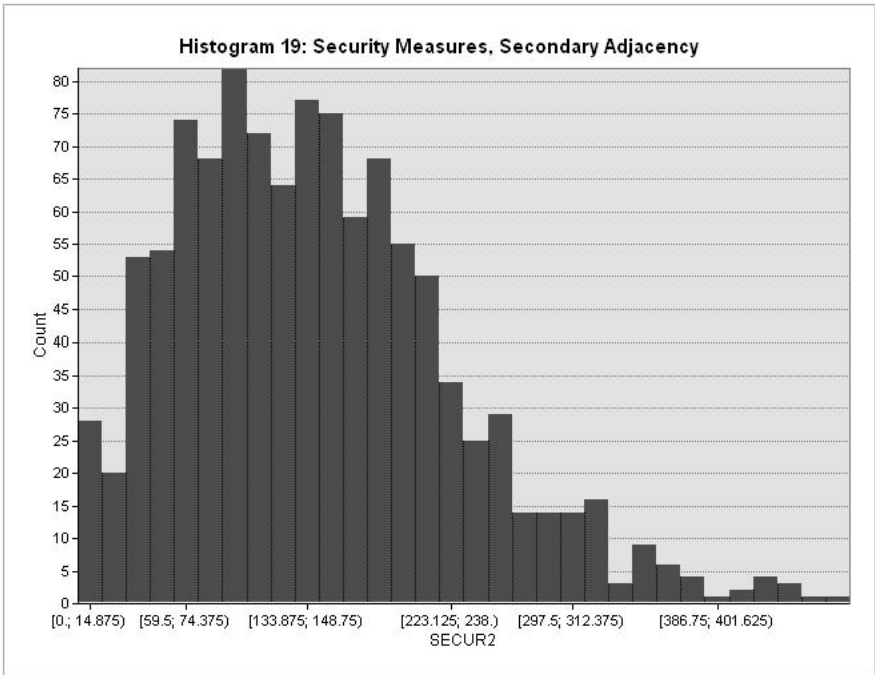

Histogram 14: Crime, Primary Adjacency
Count
CRIME1
[0.; 36.313)
[181.563; 217.875)
[399.438; 435.75)
[617.313; 653.625)
[871.5; 907.813)

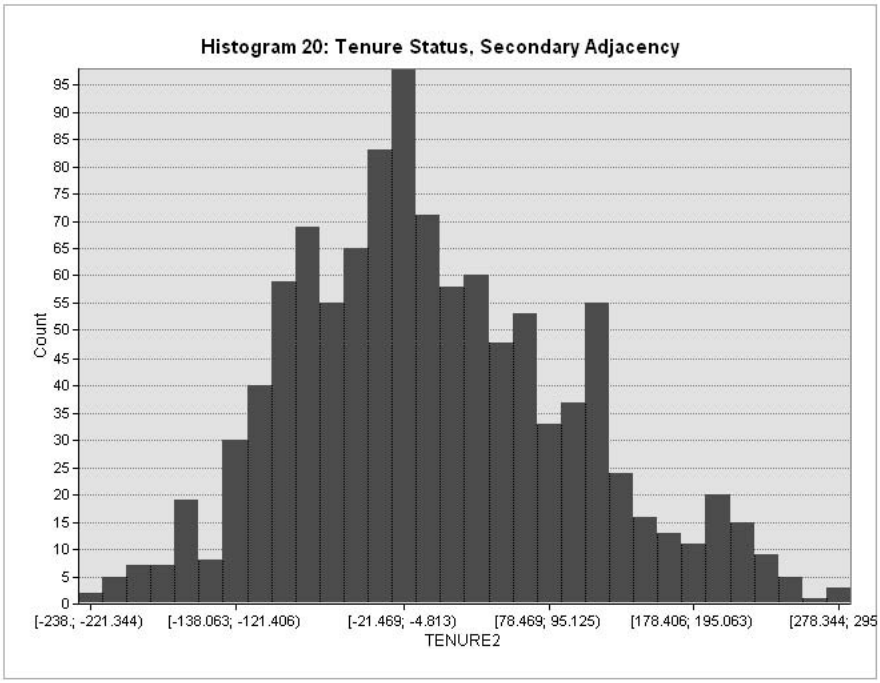

Histogram 15: Amenities, Primary Adjacency
Count
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
[0.; 0.5)
[2.; 2.5)
[4.; 4.5)
[6.; 6.5)
[8.; 8.5)
[10.; 10.5)
[12.; 12.5)
[14.; 14.5)
AMEN1

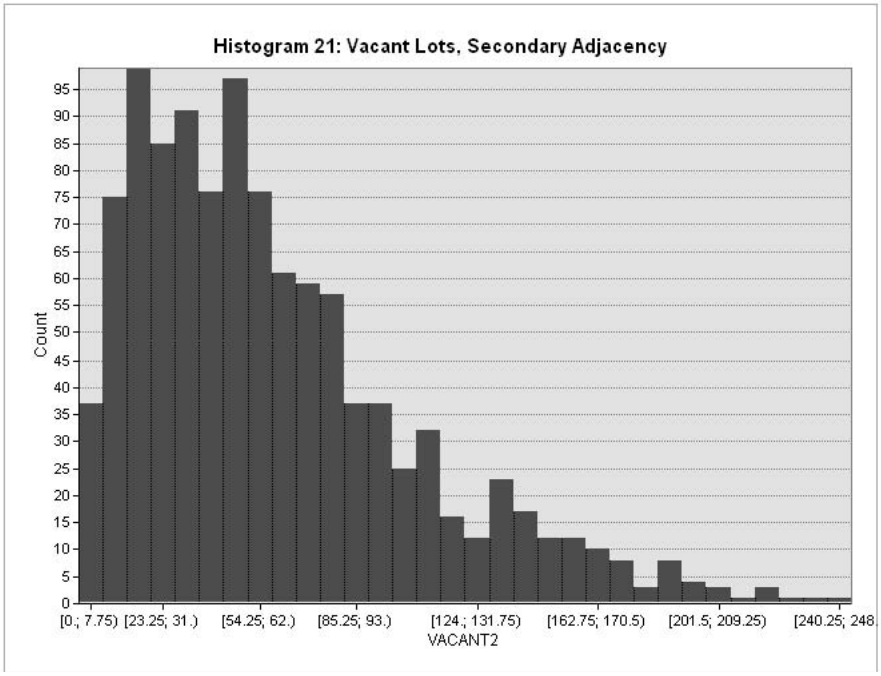

Histogram 16: Nuisances, Primary Adjacency
Count
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
[0.; 44.75)
[179.; 223.75)
[402.75; 447.5)
[626.5; 671.25)
[850.25; 895.)
[1,342.5; 1,387.25)
NUIS1

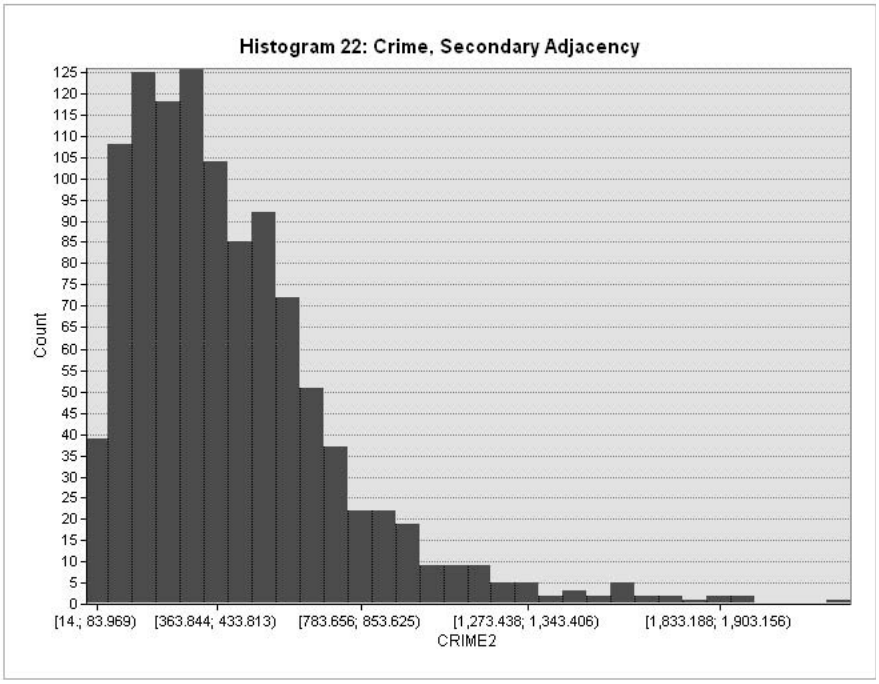

Histogram 17: Housing Damage, Secondary Adjacency
Count
HOUSE2
[0.; 16.281)
[81.406; 97.688)
[179.094; 195.375)
[276.781; 293.063)
[374.469; 390.75)
[504.719; 521

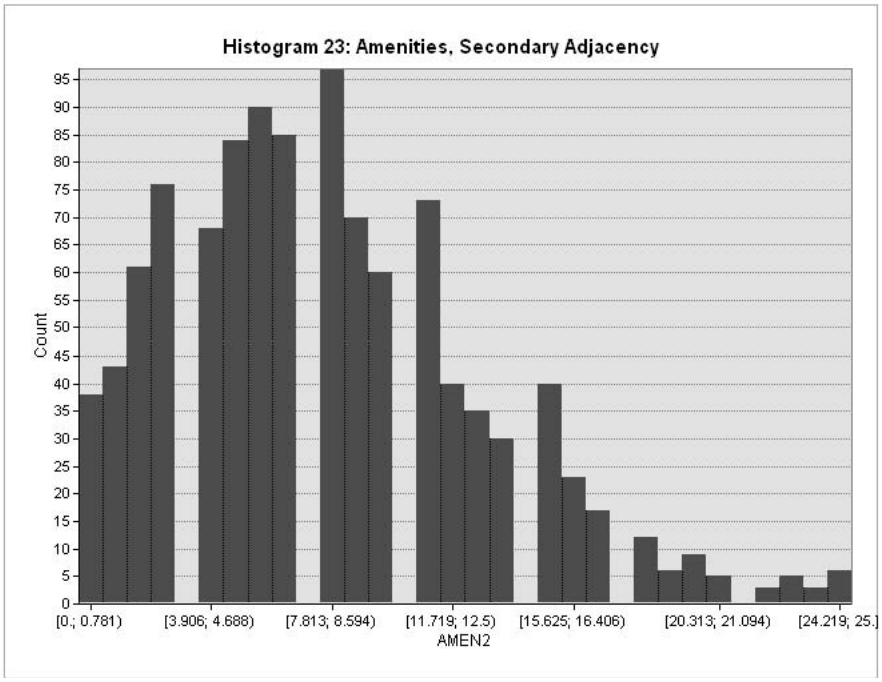

Histogram 18: Property Damage, Secondary Adjacency
Count
PROP2
[0.; 37.75)
[151.; 188.75)
[339.75; 377.5)
[528.5; 566.25)
[717.25; 755.)
[906.; 943.75)
[1,170.25; 1,20

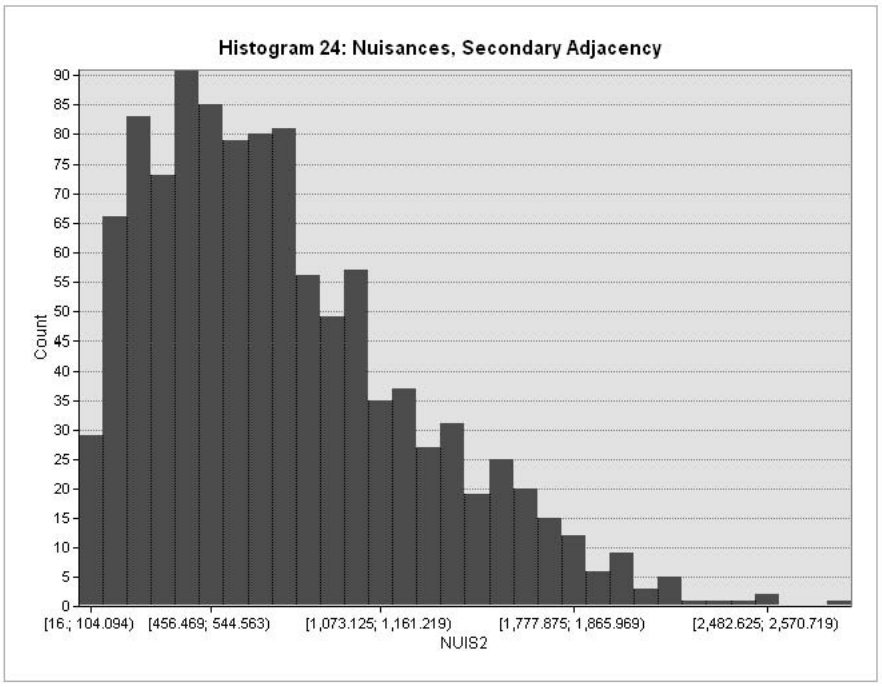

Histogram 19: Security Measures, Secondary Adjacency
Count
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
[0.; 14.875)
[59.5; 74.375)
[133.875; 148.75)
[223.125; 238.)
[297.5; 312.375)
[386.75; 401.625)
SECUR2

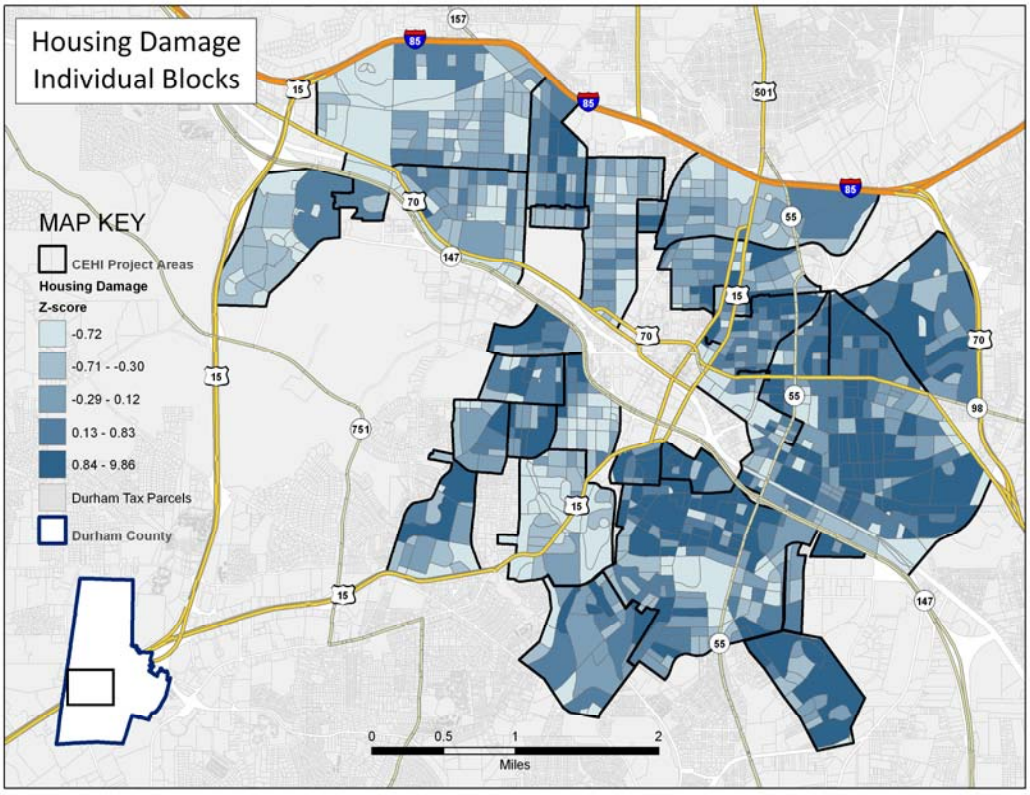

Histogram 20: Tenure Status, Secondary Adjacency
Count
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
[-238.; -221.344)
[-138.063; -121.406)
[-21.469; -4.813)
[78.469; 95.125)
[178.406; 195.063)
[278.344; 295
TENURE2


Histogram 21: Vacant Lots, Secondary Adjacency
Count
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
[0.; 7.75)
[23.25; 31.)
[54.25; 62.)
[85.25; 93.)
[124.; 131.75)
[162.75; 170.5)
[201.5; 209.25)
[240.25; 248.
VACANT2

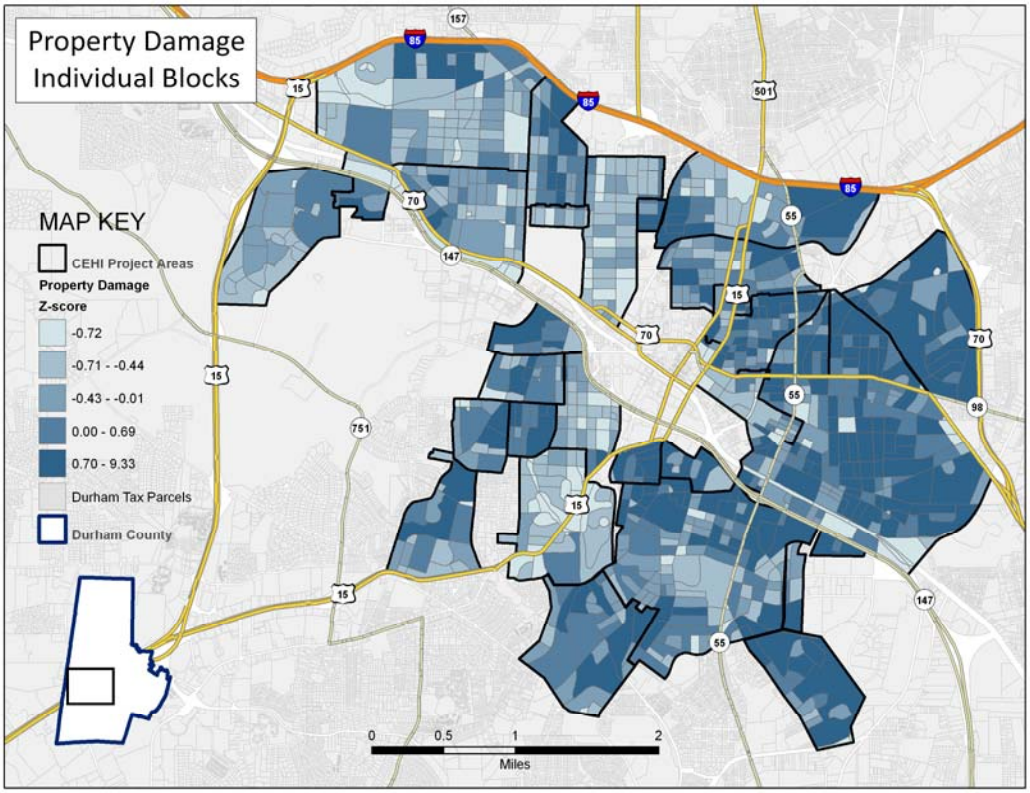

Histogram 22: Crime, Secondary Adjacency
Count
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
[14.; 83.969)
[363.844; 433.813)
[783.656; 853.625)
[1,273.438; 1,343.406)
[1,833.188; 1,903.156)
CRIME2


Histogram 23: Amenities, Secondary Adjacency
Count
AMEN2
[0.; 0.781)
[3.906; 4.688)
[7.813; 8.594)
[11.719; 12.5)
[15.625; 16.406)
[20.313; 21.094)
[24.219; 25.]

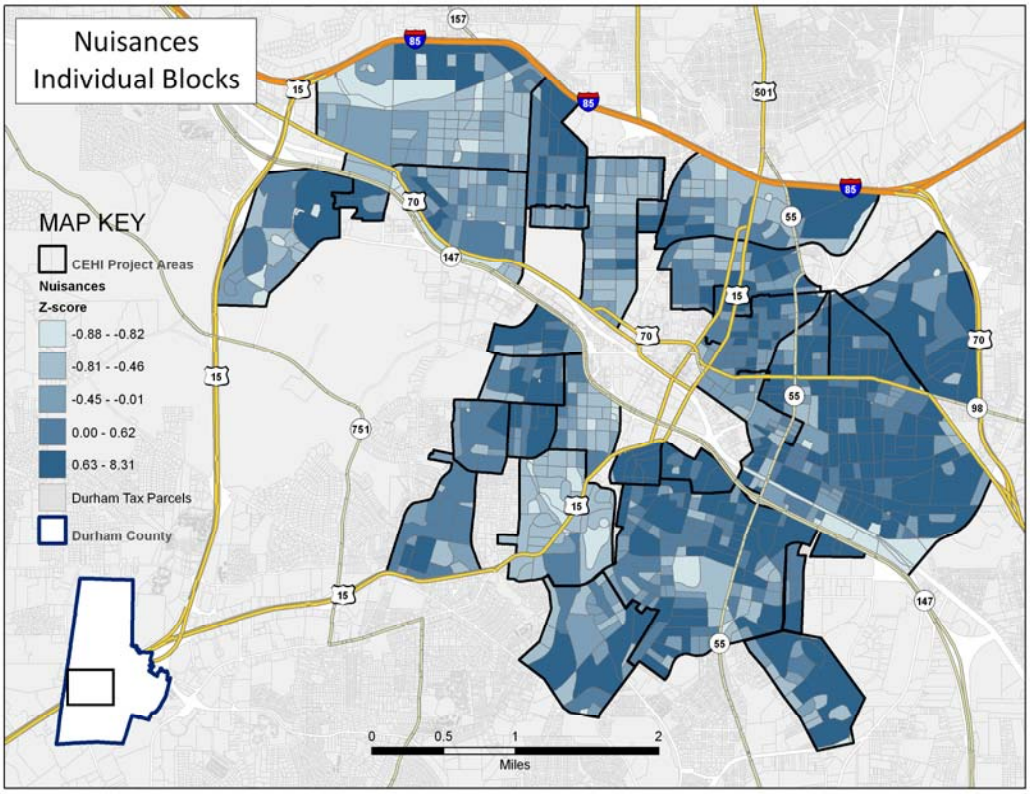

Histogram 24: Nuisances, Secondary Adjacency
Count
NUIS2
[16.; 104.094)
[456.469; 544.563)
[1,073.125; 1,161.219)
[1,777.875; 1,865.969)
[2,482.625; 2,570.719)



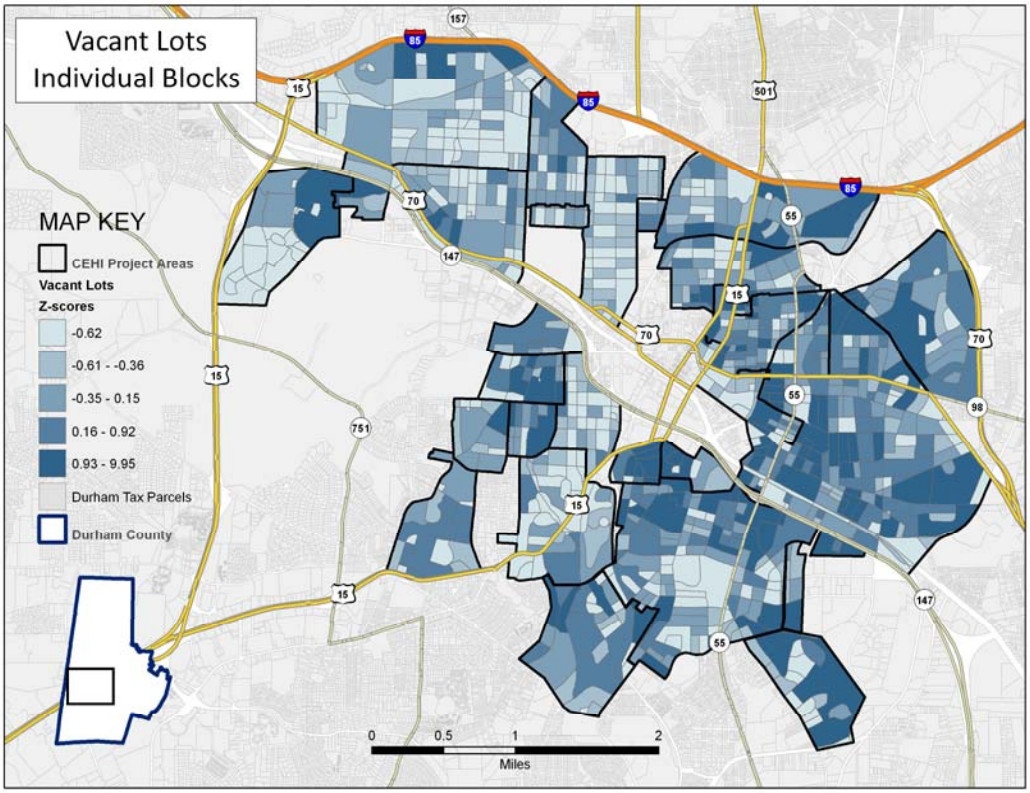
Map 2: Housing damage observed in the project area and displayed at the Census block level.



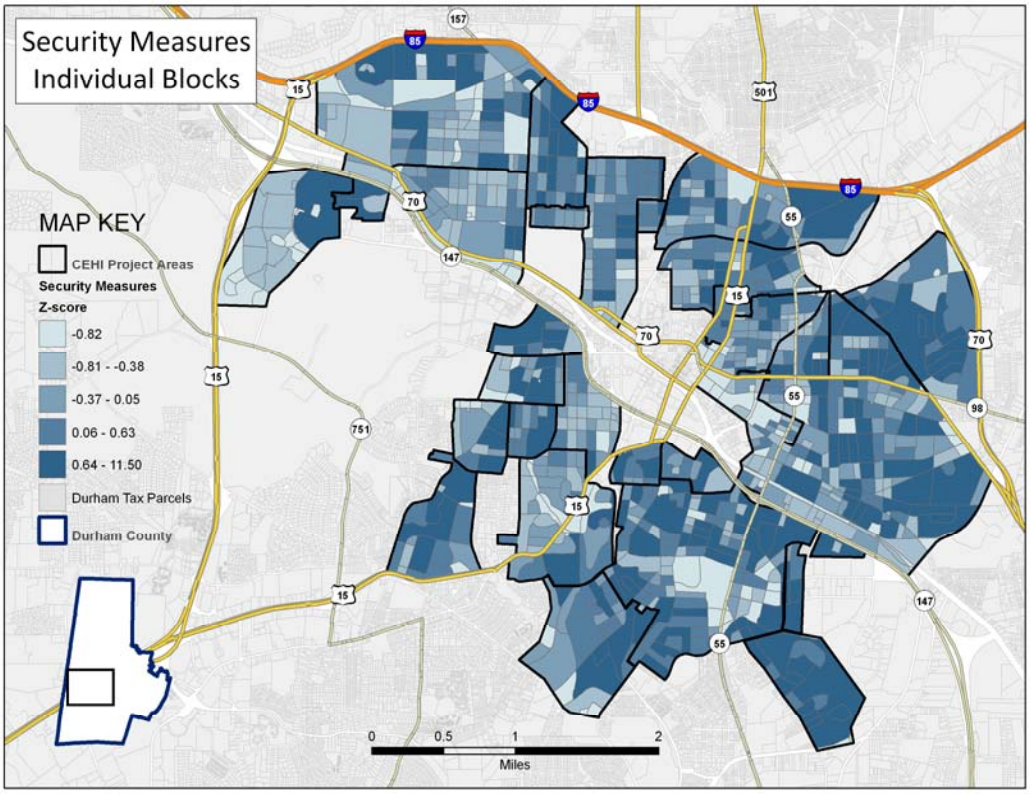
Map 3: Property damage observed in the project area and displayed at the Census block level.



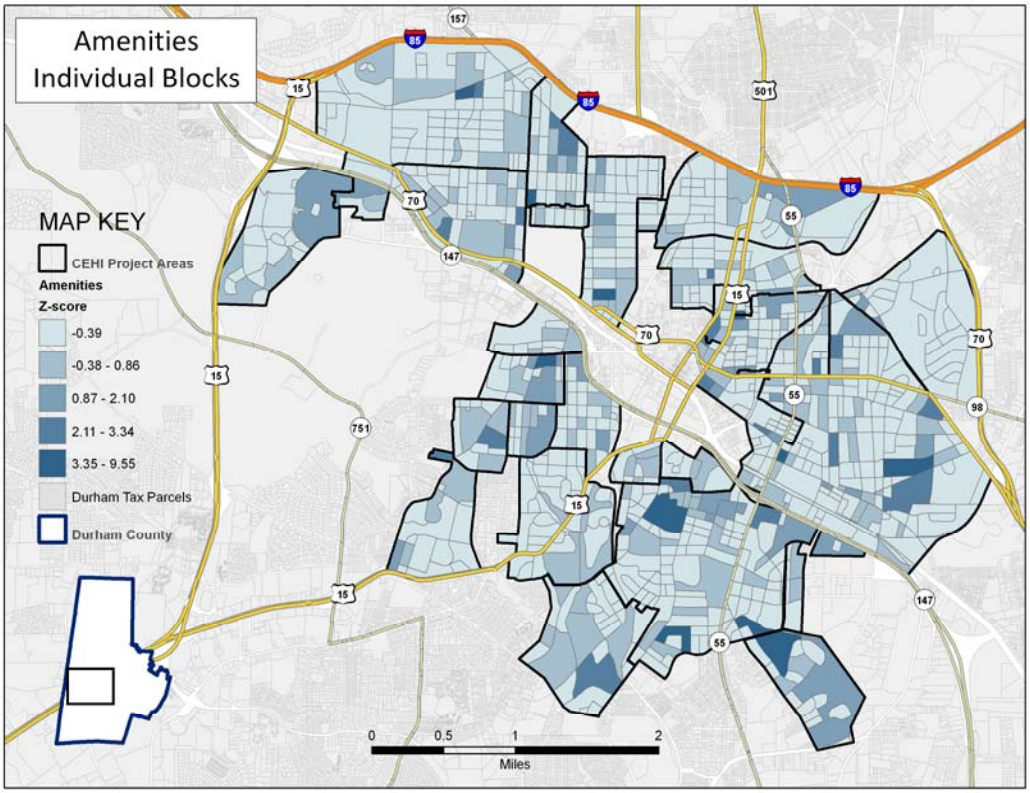
Map 4: Nuisances observed in the project area and displayed at the Census block level.



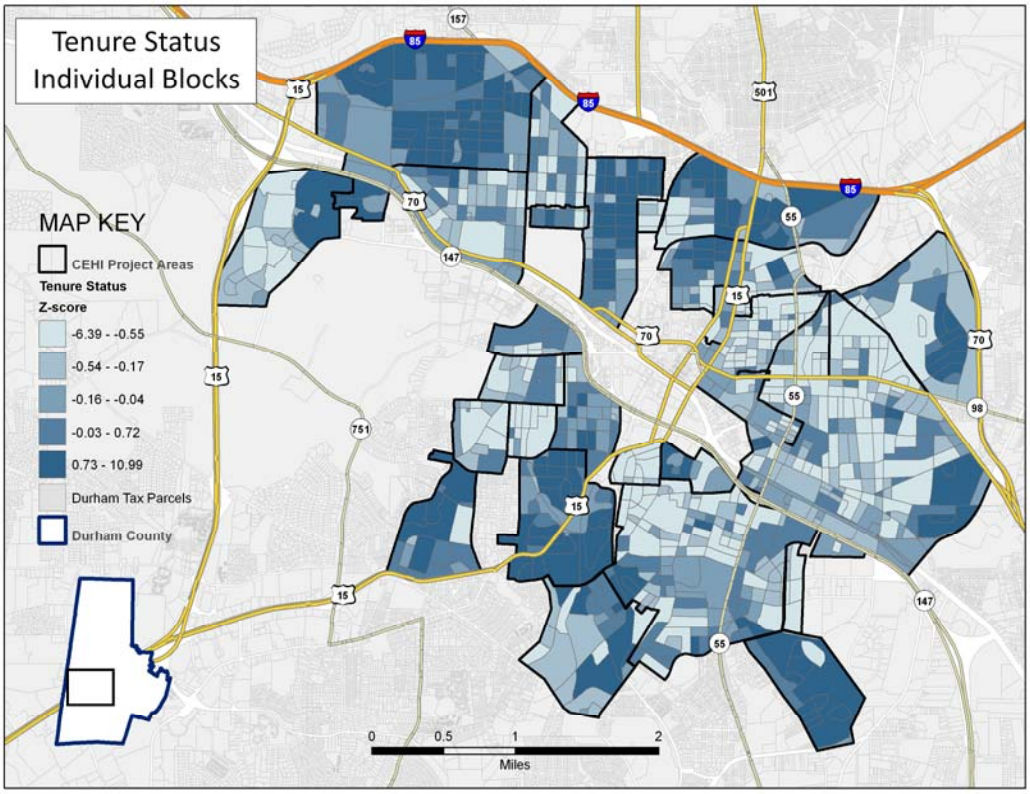
Map 5: Vacant lots observed in the project area and displayed at the Census block level.



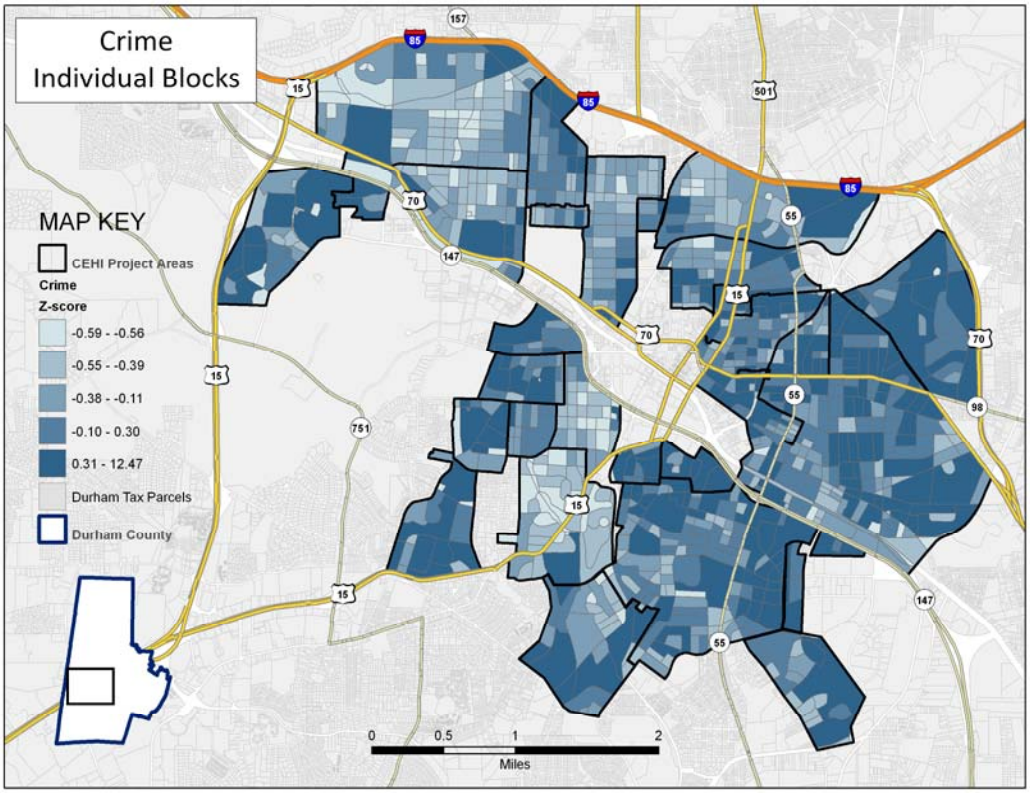
Map 6: Security measures observed in the project area and displayed at the Census block level.



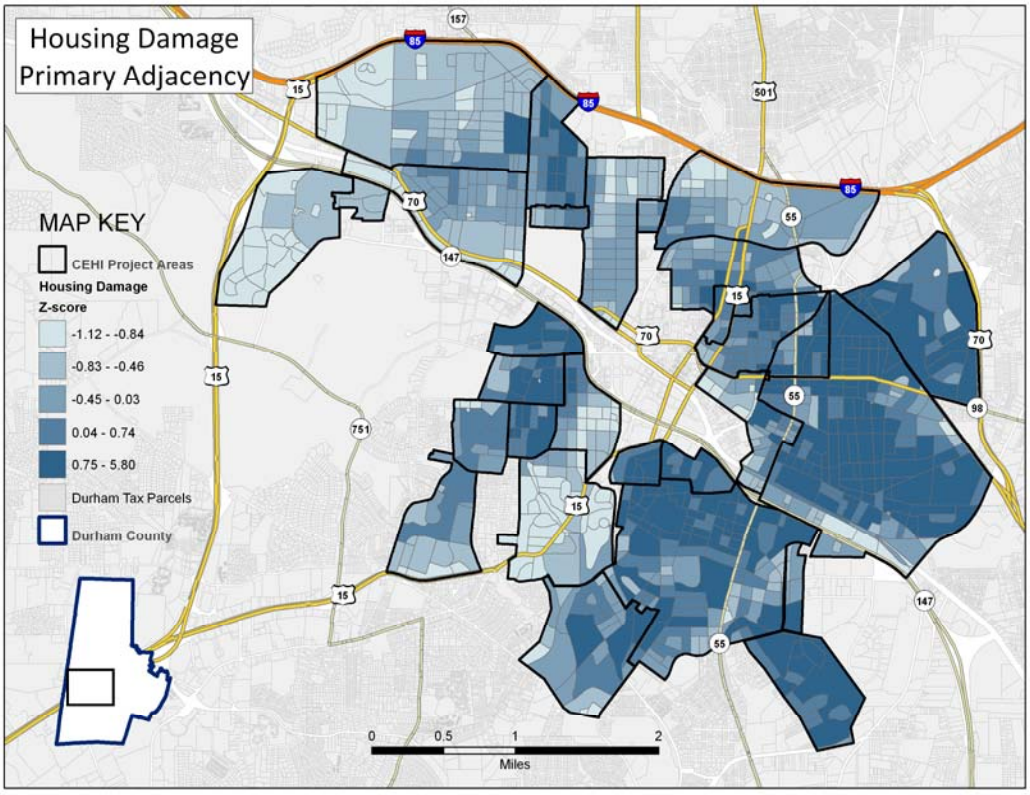
Map 7: Amenities observed in the project area and displayed at the Census block level.



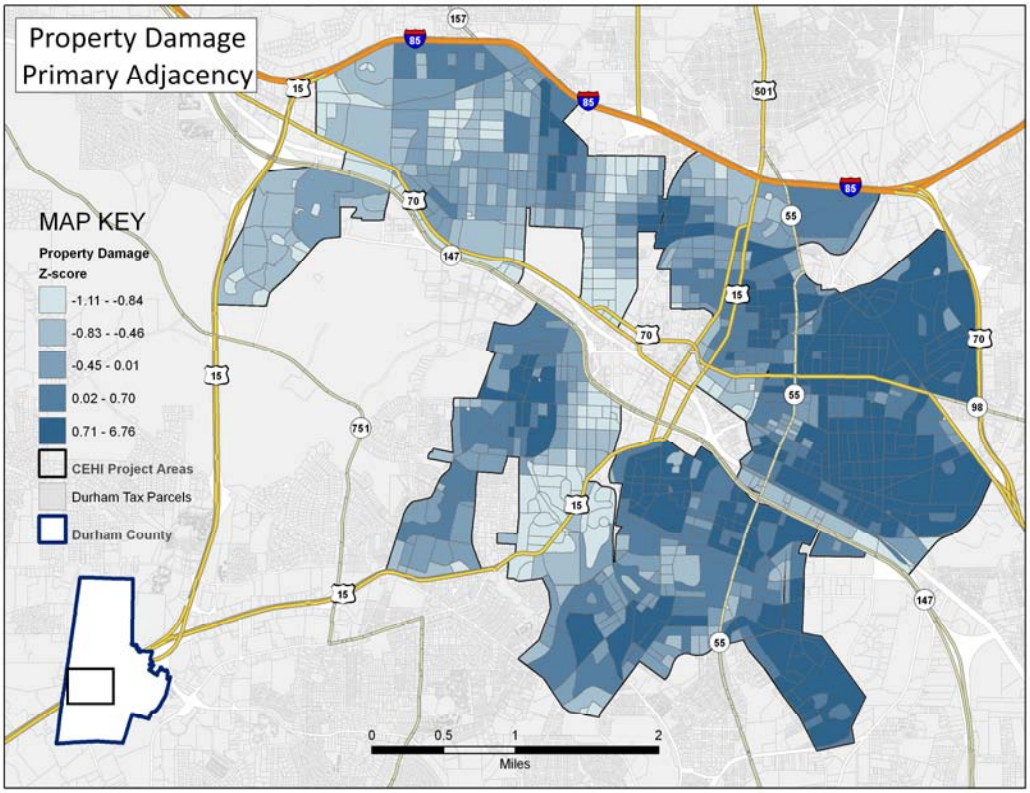
Map 8: Tenure status observed in the project area and displayed at the Census block level.



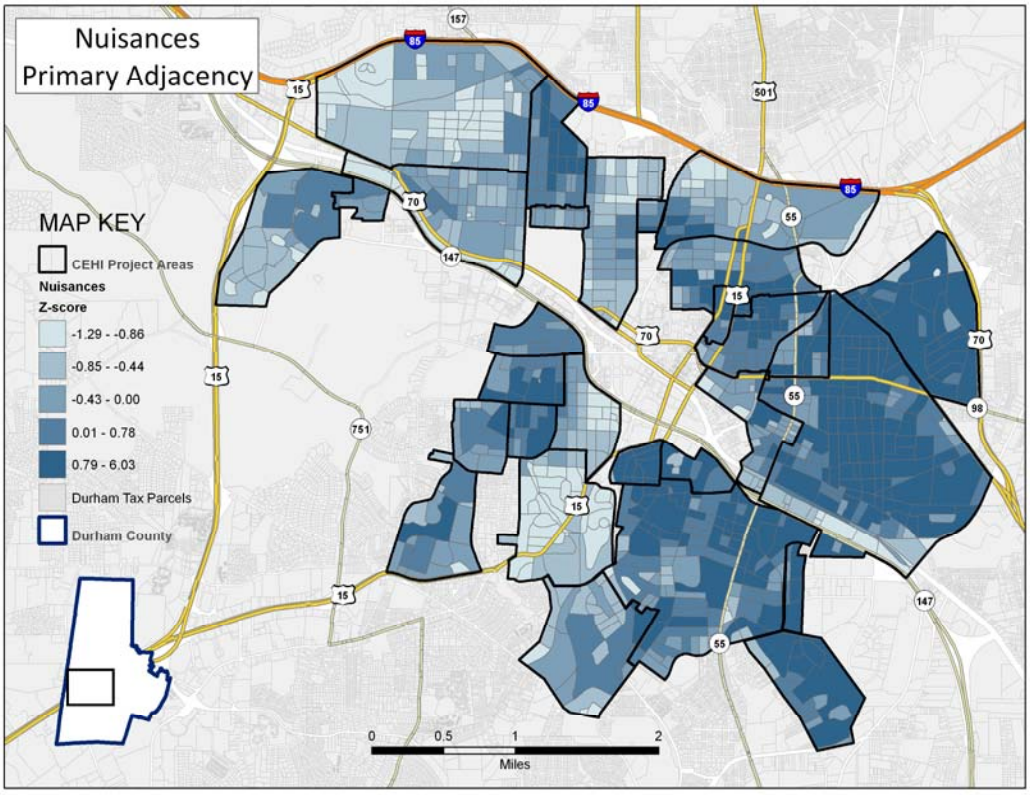
Map 9: Crime reported in the project area and displayed at the Census block level.



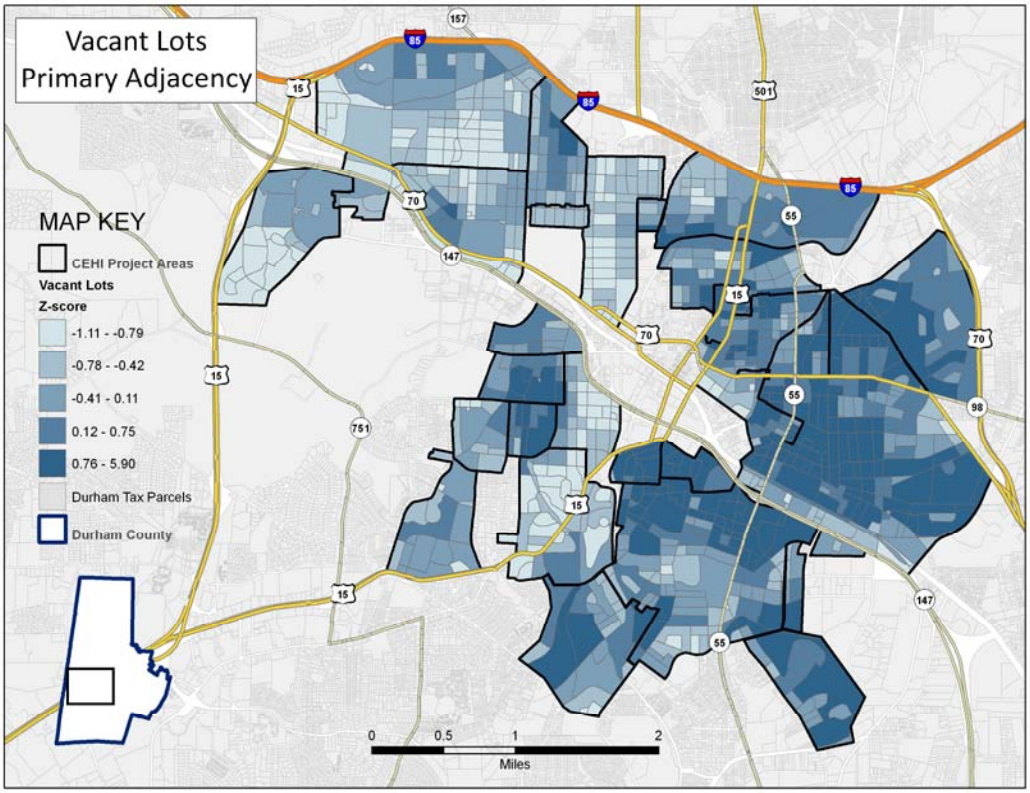
Map 10: Housing damage observed in the project area and summed at the primary adjacency level.



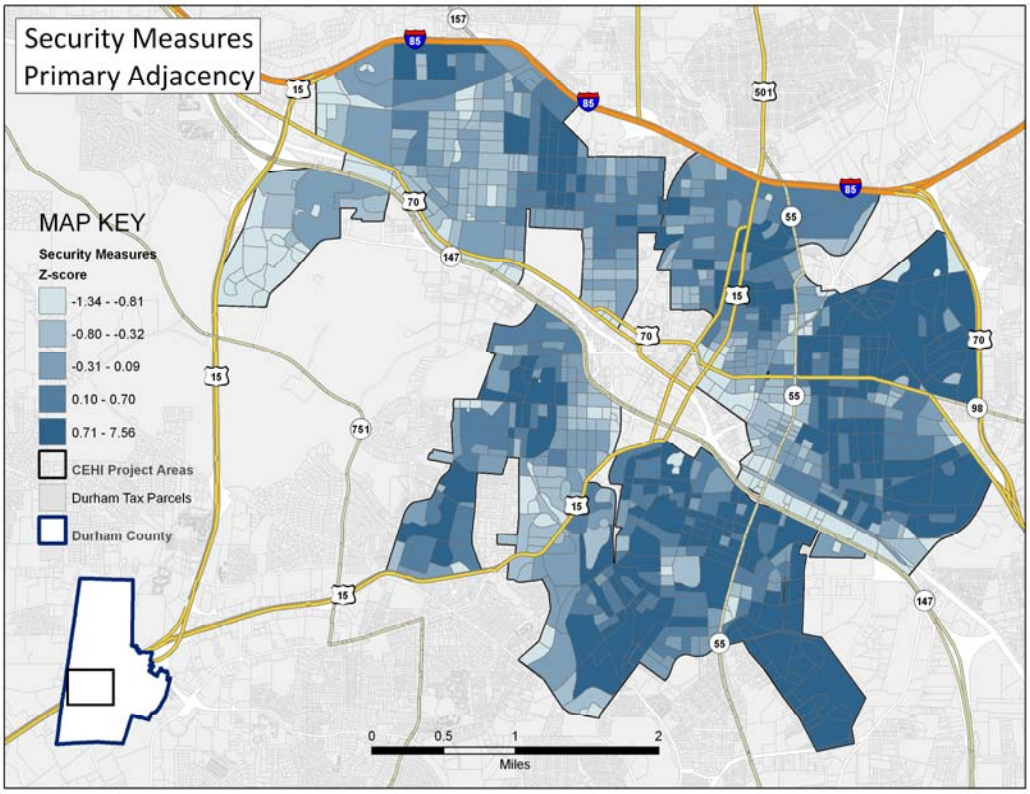
Map 11: Property damage observed in the project area and summed at the primary adjacency level.



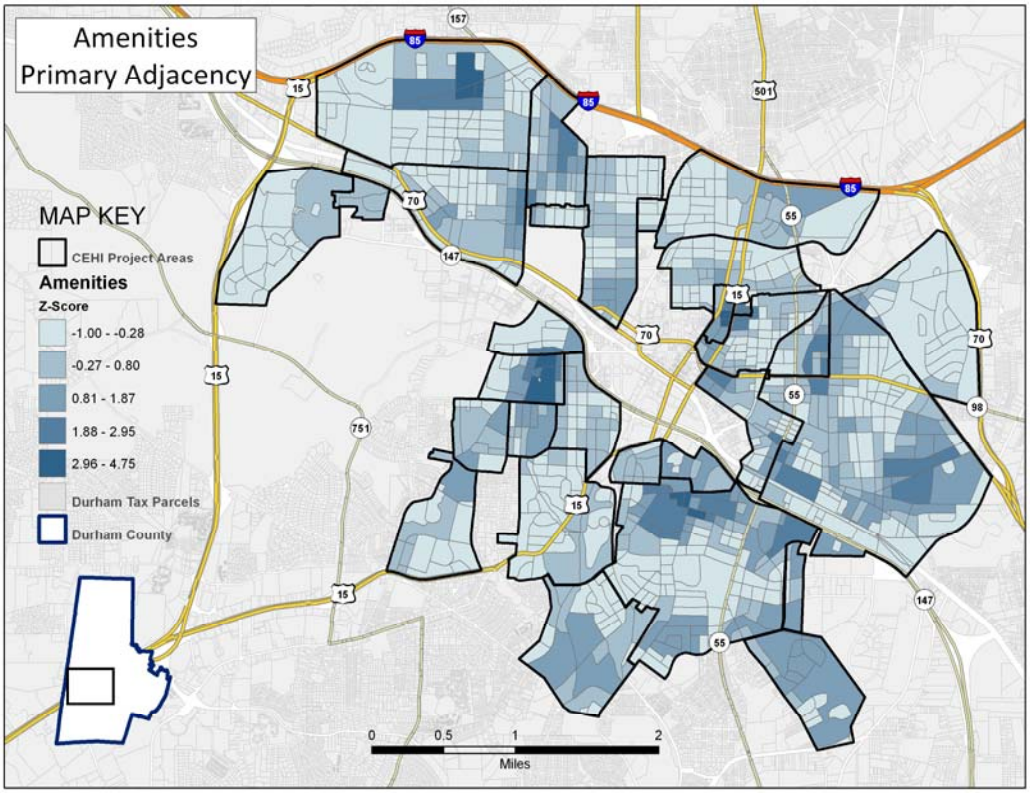
Map 12: Nuisances observed in the project area and summed at the primary adjacency level.



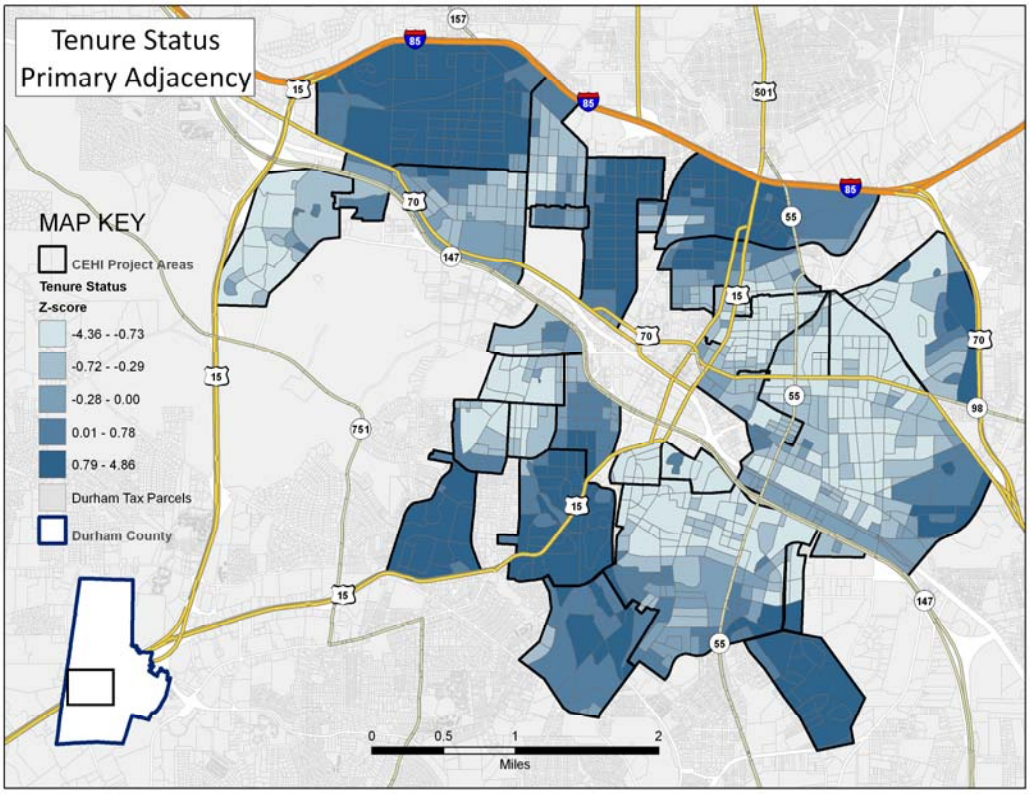
Map 13: Vacant lots observed in the project area and summed at the primary adjacency level.



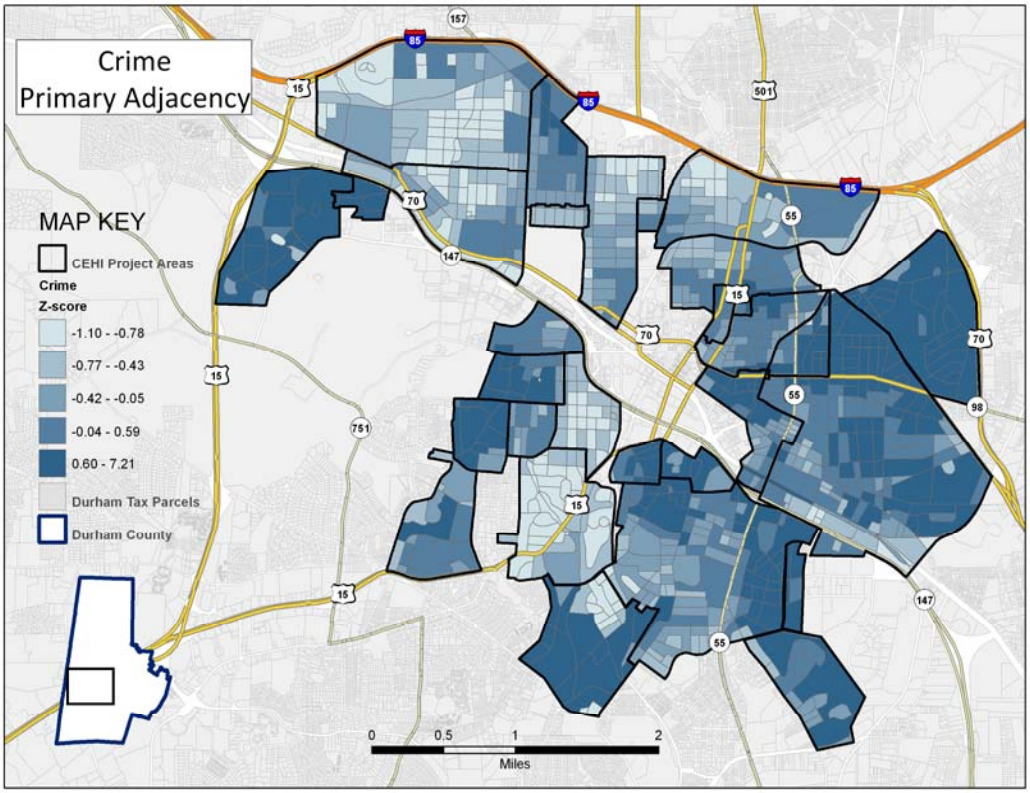
Map 14: Security measures observed in the project area and summed at the primary adjacency level.



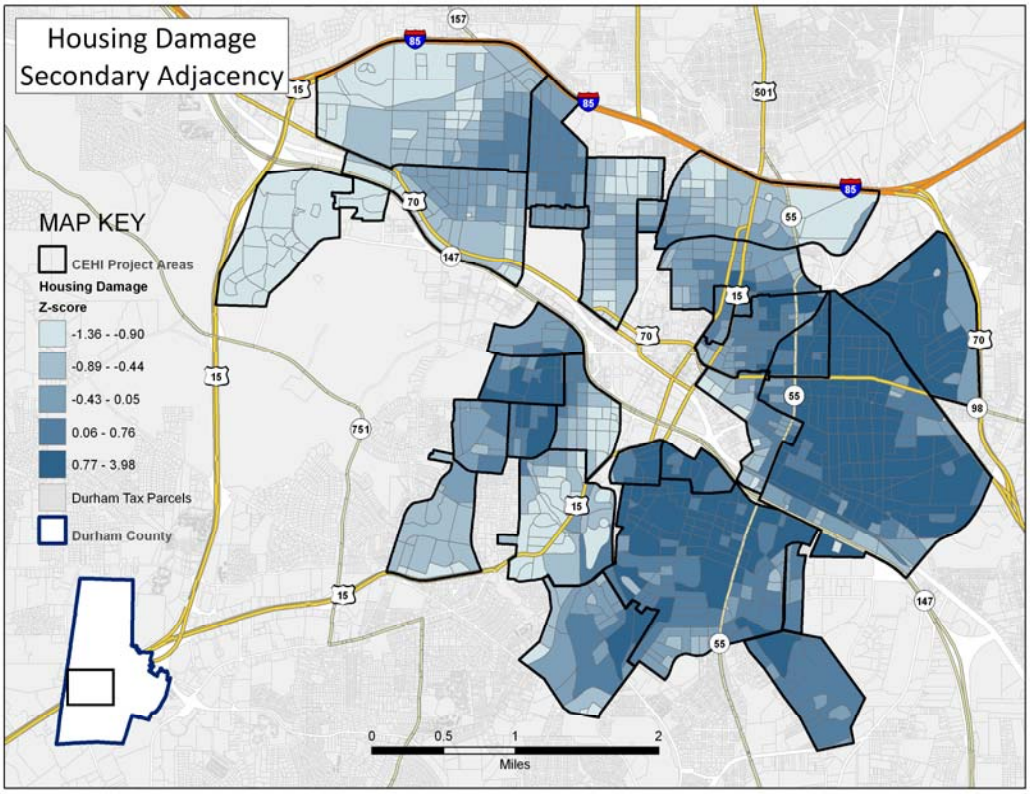
Map 15: Amenities observed in the project area and summed at the primary adjacency level.



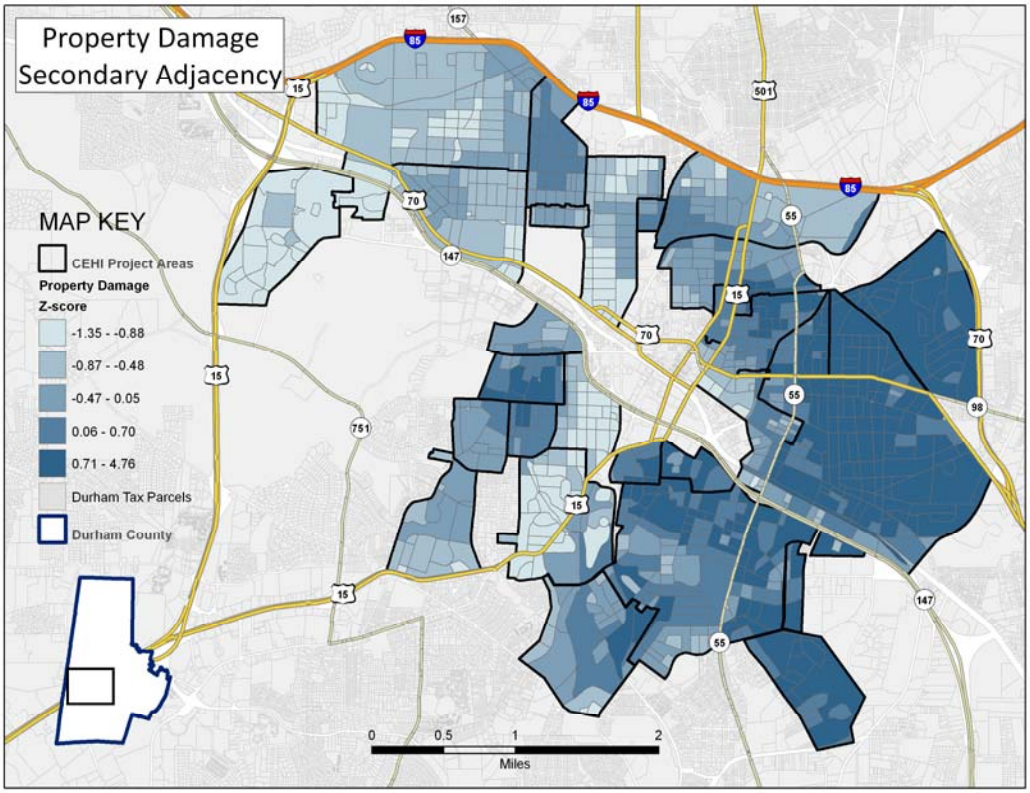
Map 16: Tenure status observed in the project area and summed at the primary adjacency level.



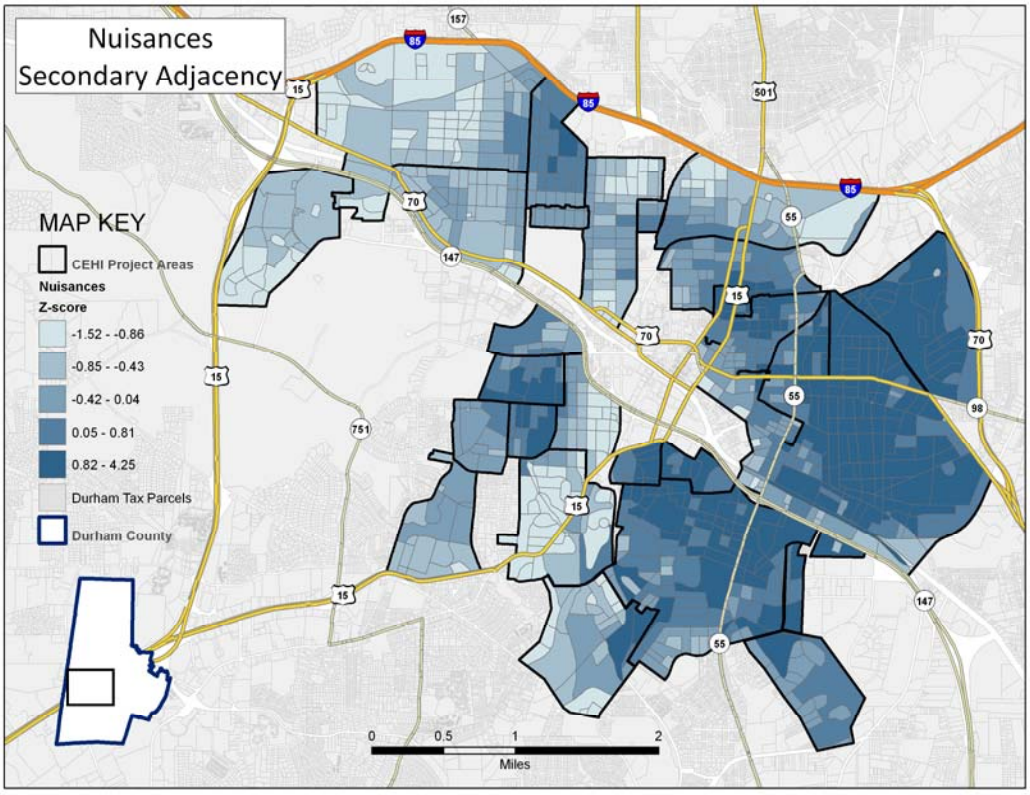
Map 17: Crime reported in the project area and summed at the primary adjacency level.



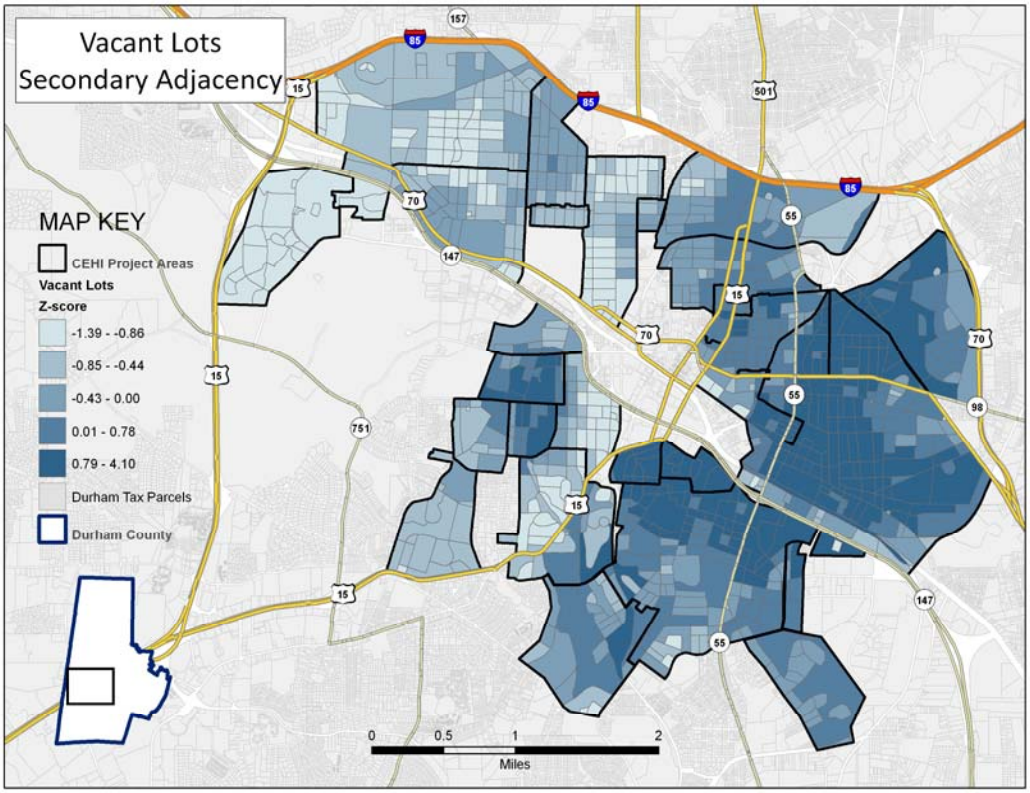
Map 18: Housing damage observed in the project area and summed at the secondary adjacency level.



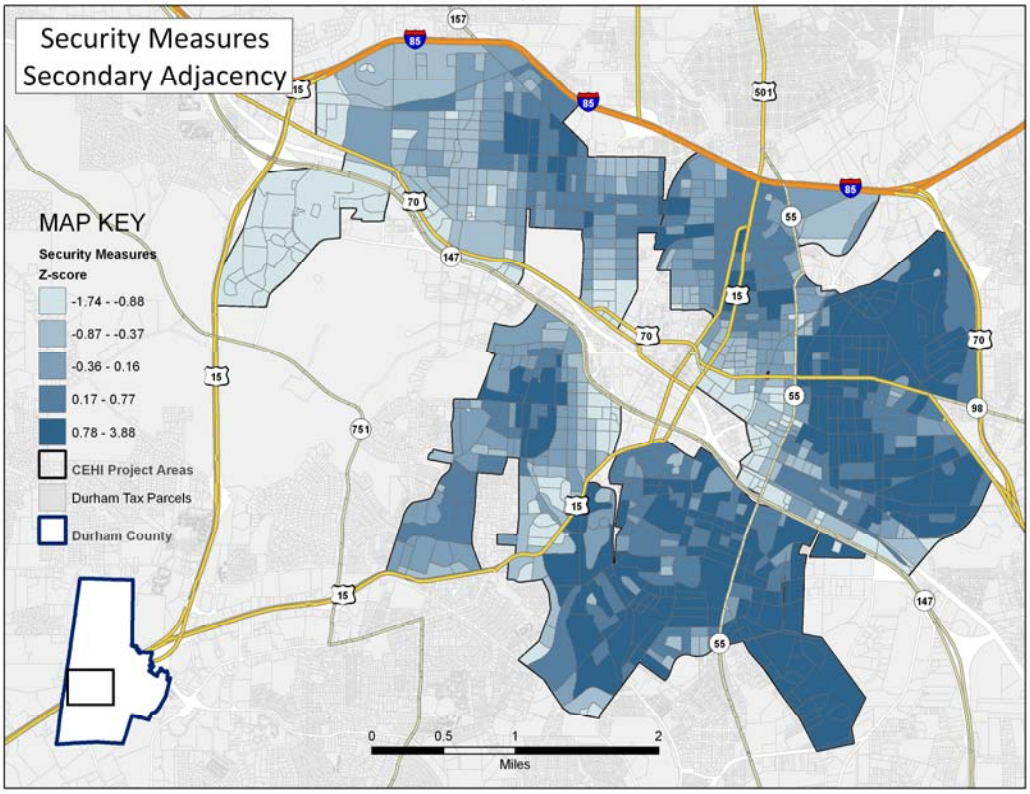
Map 19: Property damage observed in the project area and summed at the secondary adjacency level.



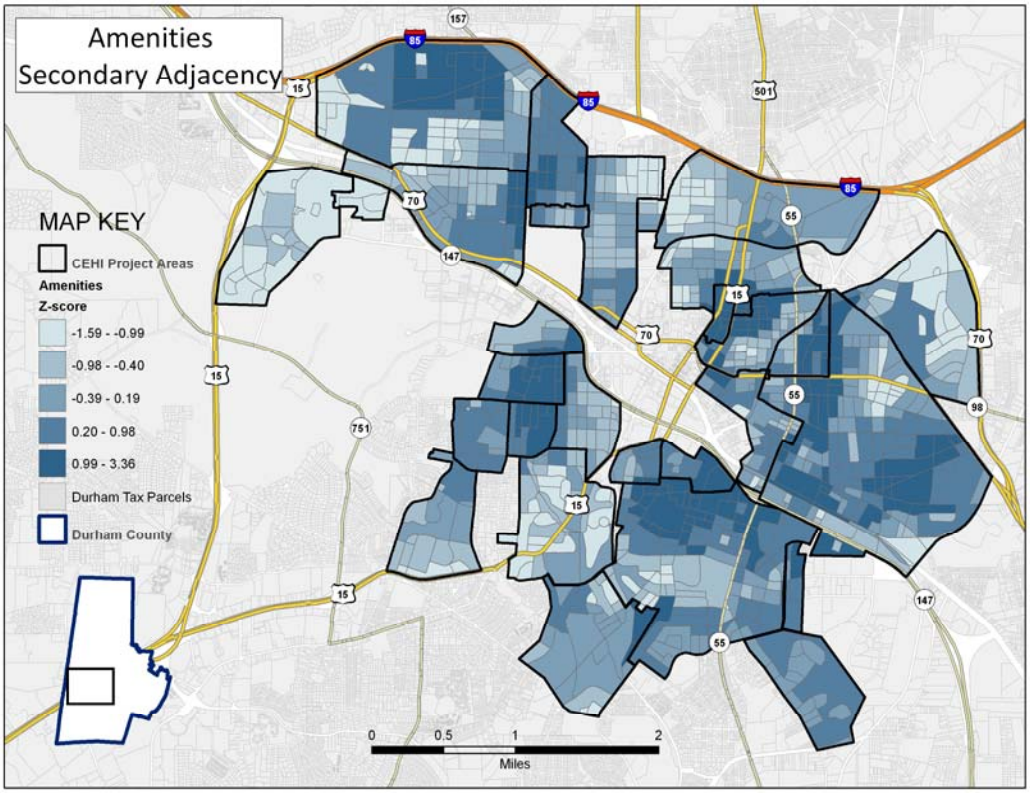
Map 20: Nuisances observed in the project area and summed at the secondary adjacency level.



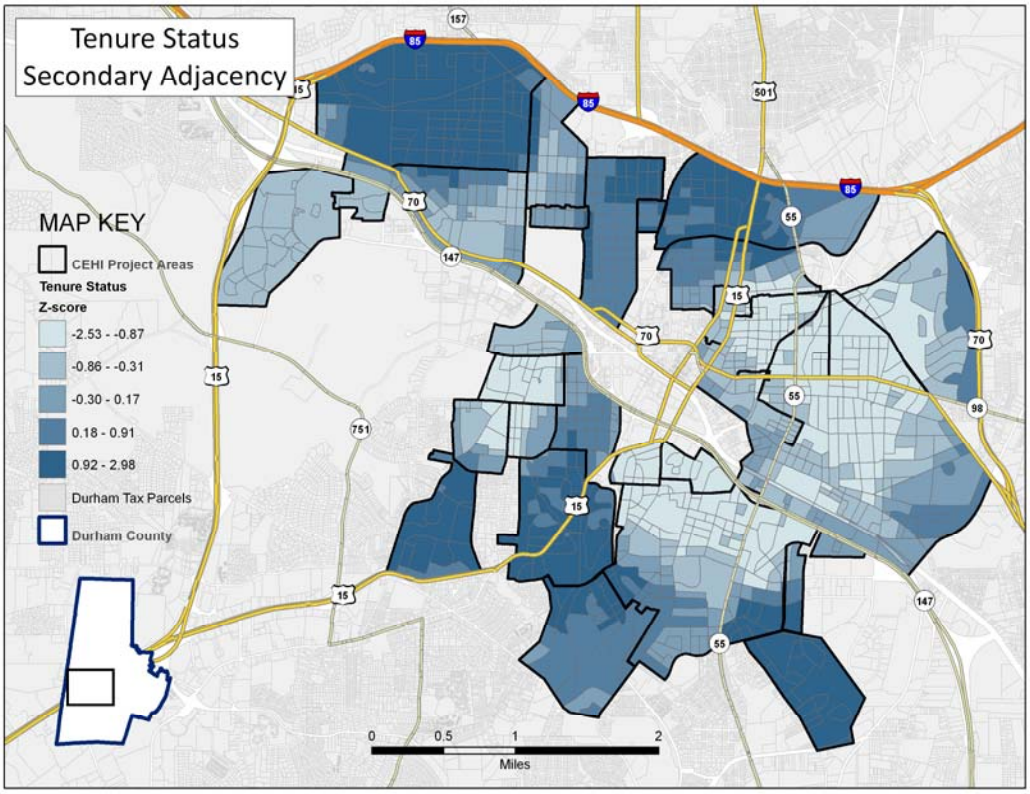
Map 21: Vacant lots observed in the project area and summed at the secondary adjacency level.



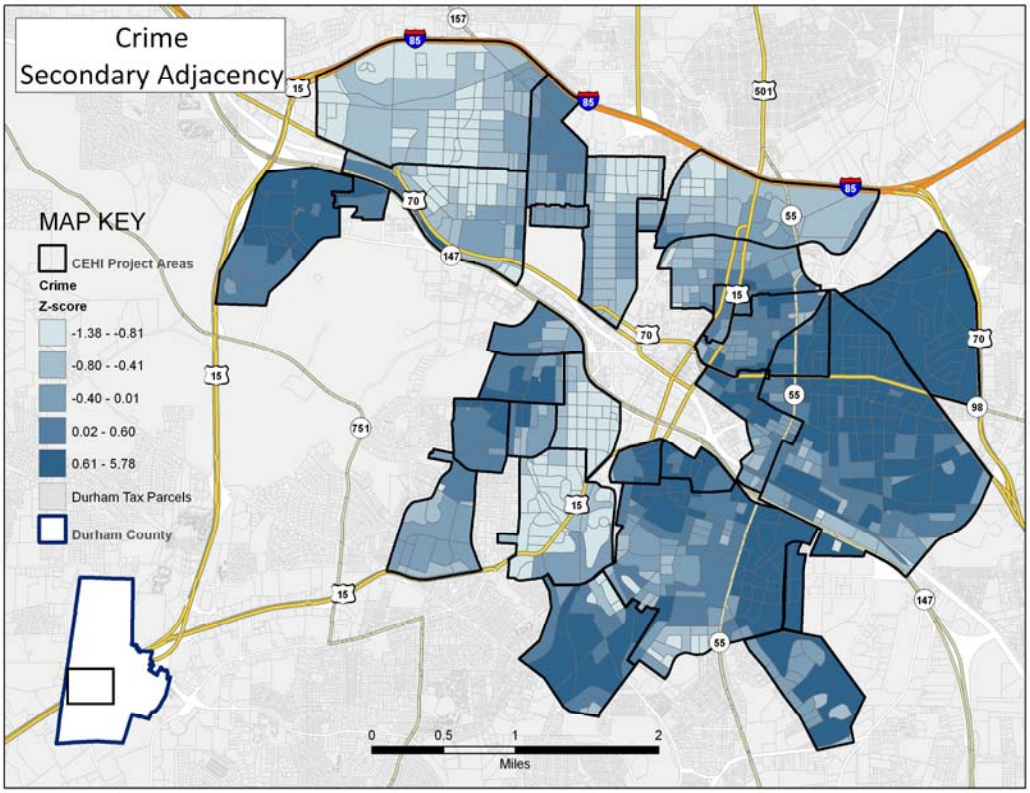
Map 22: Security measures observed in the project area and summed at the secondary adjacency level.



Map 23: Amenities observed in the project area and summed at the secondary adjacency level.



Map 24: Tenure status observed in the project area and summed at the secondary adjacency level.



Map 25: Crime reported in the project area and summed at the secondary adjacency level.

	Housing Damage	Property	Security	Tenure	Vacant	Nuisance	Crime	Amenities	Median Age	Female-headed Households (%)	Black (%)	Single Parent Families (%)	Hispanic (%)	Minority (%)	Property Tax Value	Median Income	Public Assistance (%)	Children in Poverty (%)	Median Year Built
Housing Damage	1	0.84105 <.0001	0.67345 <.0001	-0.24629 <.0001	0.64716 <.0001	0.80612 <.0001	0.37895 <.0001	0.22123 <.0001	0.14666 <.0001	0.06663 0.0328	0.40826 <.0001	0.2734 <.0001	0.18818 <.0001	0.4387 <.0001	-0.10507 0.0007	-0.25239 <.0001	0.24058 <.0001	0.2302 <.0001	-0.04555 0.1446
Property	0.84105 <.0001	1	0.70922 <.0001	-0.23679 <.0001	0.69471 <.0001	0.8702 <.0001	0.45885 <.0001	0.21013 <.0001	0.11431 0.0002	0.0671 0.0315	0.41437 <.0001	0.29046 <.0001	0.21755 <.0001	0.45572 <.0001	-0.09337 0.0027	-0.25169 <.0001	0.2456 <.0001	0.22951 <.0001	0.02563 0.412
Security	0.67345 <.0001	0.70922 <.0001	1	0.13448 <.0001	0.50436 <.0001	0.69139 <.0001	0.35693 <.0001	0.23751 <.0001	0.22146 <.0001	0.13709 <.0001	0.32713 <.0001	0.18375 <.0001	0.07043 0.024	0.33683 <.0001	-0.09924 0.0015	-0.03959 0.205	0.11537 0.0002	0.06226 0.0461	-0.01705 0.5852
Tenure Status	-0.24629 <.0001	-0.23679 <.0001	0.13448 <.0001	1	-0.21935 <.0001	-0.29261 <.0001	-0.17451 <.0001	-0.08352 0.0074	0.13453 <.0001	0.07432 0.0172	-0.24517 <.0001	-0.21767 <.0001	-0.17557 <.0001	-0.28297 <.0001	0.00021 0.9946	0.38179 <.0001	-0.27729 <.0001	-0.32466 <.0001	-0.07588 0.015
Vacant	0.64716 <.0001	0.69471 <.0001	0.50436 <.0001	-0.21935 <.0001	1	0.69645 <.0001	0.34889 <.0001	0.16551 <.0001	0.06724 0.0312	0.07472 0.0166	0.33845 <.0001	0.26344 <.0001	0.18646 <.0001	0.36153 <.0001	-0.08788 0.0048	-0.23782 <.0001	0.26467 <.0001	0.18585 <.0001	0.03473 0.2661
Nuisance	0.80612 <.0001	0.8702 <.0001	0.69139 <.0001	-0.29261 <.0001	0.69645 <.0001	1	0.53279 <.0001	0.28459 <.0001	0.1217 <.0001	0.10729 0.0006	0.42165 <.0001	0.3268 <.0001	0.23787 <.0001	0.47166 <.0001	-0.07238 0.0204	-0.27036 <.0001	0.27547 <.0001	0.23087 <.0001	0.01114 0.7213
Crime	0.37895 <.0001	0.45885 <.0001	0.35693 <.0001	-0.17451 <.0001	0.34889 <.0001	0.53279 <.0001	1	0.19509 <.0001	-0.02336 0.4546	0.36906 <.0001	0.2317 <.0001	0.31995 <.0001	0.20302 <.0001	0.27601 <.0001	0.09677 0.0019	-0.18334 <.0001	0.21462 <.0001	0.14913 <.0001	0.10748 0.0006
Amenities	0.22123 <.0001	0.21013 <.0001	0.23751 <.0001	-0.08352 0.0074	0.16551 <.0001	0.28459 <.0001	0.19509 <.0001	1	0.03803 0.2233	0.03263 0.2962	0.08376 0.0072	0.05128 0.1005	0.08521 0.0063	0.10616 0.0007	0.03971 0.2035	-0.06096 0.0508	0.04756 0.1277	0.05191 0.0964	0.01511 0.6286

Table 4: Pearson's Correlation Coefficients within Individual Census Blocks and between Census Blocks and Demographic Variables

	Housing Damage	Property	Security	Tenure	Vacant	Nuisances	Crime	Amenities	Median Age	Female-headed Households (%)	Black (%)	Single Parent Families (%)	Hispanic (%)	Minority (%)	Property Tax Value	Median Income	Public Assistance (%)	Children in Poverty (%)	Median Year Built
Housing Damage	1	0.91353 <.0001	0.74467 <.0001	-0.45359 <.0001	0.76301 <.0001	0.91718 <.0001	0.4976 <.0001	0.42773 <.0001	0.09616 0.002	-0.016 0.6084	0.47028 <.0001	0.27496 <.0001	0.1852 <.0001	0.49836 <.0001	-0.06855 0.028	-0.3477 <.0001	0.35414 <.0001	0.32549 <.0001	-0.03975 0.2031
Property	0.91353 <.0001	1	0.77069 <.0001	-0.43669 <.0001	0.77464 <.0001	0.94221 <.0001	0.6109 <.0001	0.36835 <.0001	0.07044 0.024	-0.00605 0.8463	0.46191 <.0001	0.27483 <.0001	0.22159 <.0001	0.49931 <.0001	-0.09 0.0039	-0.3245 <.0001	0.35241 <.0001	0.30695 <.0001	0.04331 0.1655
Security	0.74467 <.0001	0.77069 <.0001	1	0.00143 0.9635	0.57161 <.0001	0.74615 <.0001	0.4518 <.0001	0.38674 <.0001	0.19816 <.0001	0.05518 0.0772	0.39783 <.0001	0.18864 <.0001	0.0643 0.0394	0.40097 <.0001	-0.06221 0.0462	-0.05912 0.0582	0.1769 <.0001	0.09524 0.0022	-0.01626 0.6026
Tenure	-0.45359 <.0001	-0.43669 <.0001	0.00143 0.9635	1	-0.47086 <.0001	-0.5204 <.0001	-0.39823 <.0001	-0.20041 <.0001	0.14501 <.0001	0.05172 0.0976	-0.35541 <.0001	-0.29113 <.0001	-0.21053 <.0001	-0.39973 <.0001	0.03498 0.2628	0.54689 <.0001	-0.42326 <.0001	-0.46517 <.0001	-0.1177 0.0002
Vacant	0.76301 <.0001	0.77464 <.0001	0.57161 <.0001	-0.47086 <.0001	1	0.80713 <.0001	0.4727 <.0001	0.39526 <.0001	0.018 0.5645	-0.01821 0.5599	0.43857 <.0001	0.29116 <.0001	0.18663 <.0001	0.45188 <.0001	-0.09391 0.0026	-0.36615 <.0001	0.4289 <.0001	0.29287 <.0001	0.09832 0.0016
Nuisances	0.91718 <.0001	0.94221 <.0001	0.74615 <.0001	-0.5204 <.0001	0.80713 <.0001	1	0.65788 <.0001	0.45241 <.0001	0.06407 0.0401	0.01897 0.5436	0.4764 <.0001	0.31411 <.0001	0.23042 <.0001	0.52032 <.0001	-0.06136 0.0493	-0.36058 <.0001	0.38358 <.0001	0.31598 <.0001	0.02527 0.4185
Crime	0.4976 <.0001	0.6109 <.0001	0.4518 <.0001	-0.39823 <.0001	0.4727 <.0001	0.65788 <.0001	1	0.24978 <.0001	-0.03189 0.3072	0.18107 <.0001	0.33646 <.0001	0.30589 <.0001	0.17767 <.0001	0.38182 <.0001	0.06062 0.0521	-0.29934 <.0001	0.34596 <.0001	0.21806 <.0001	0.23588 <.0001
Amenities	0.42773 <.0001	0.36835 <.0001	0.38674 <.0001	-0.20041 <.0001	0.39526 <.0001	0.45241 <.0001	0.24978 <.0001	1	0.04905 0.1162	-0.0011 0.9718	0.22457 <.0001	0.16233 <.0001	0.07958 0.0107	0.23971 <.0001	0.00903 0.7725	-0.18747 <.0001	0.15852 <.0001	0.17784 <.0001	0.01419 0.6497

Table 5: Pearson's Correlation Coefficients between Primarily Adjacent Blocks and Demographic Variables

	Housing Damage	Property	Security	Tenure	Vacant	Nuisances	Crime	Amenities	Median Age	Female-headed Households (%)	Black (%)	Single Parent Families (%)	Hispanic (%)	Minority (%)	Property Tax Value	Median Income	Public Assistance (%)	Children in Poverty (%)	Median Year Built
Housing Damage	1	0.9346 <.0001	0.7599 <.0001	-0.58509 <.0001	0.83819 <.0001	0.95063 <.0001	0.6721 <.0001	0.55942 <.0001	0.04102 0.189	-0.07488 0.0164	0.46163 <.0001	0.27181 <.0001	0.17519 <.0001	0.48345 <.0001	-0.08269 0.008	-0.37552 <.0001	0.40569 <.0001	0.33793 <.0001	-0.04197 0.179
Property	0.9346 <.0001	1	0.77343 <.0001	-0.55395 <.0001	0.82145 <.0001	0.9603 <.0001	0.77812 <.0001	0.45229 <.0001	0.01918 0.5393	-0.06534 0.0363	0.45394 <.0001	0.26789 <.0001	0.19829 <.0001	0.48165 <.0001	-0.0985 0.0016	-0.35188 <.0001	0.40117 <.0001	0.32377 <.0001	0.03373 0.2802
Security	0.7599 <.0001	0.77343 <.0001	1	-0.10341 0.0009	0.57434 <.0001	0.7529 <.0001	0.56551 <.0001	0.42394 <.0001	0.15521 <.0001	-0.03213 0.3037	0.42811 <.0001	0.18695 <.0001	0.06334 0.0424	0.42503 <.0001	-0.09333 0.0028	-0.08619 0.0057	0.21434 <.0001	0.11655 0.0002	-0.05052 0.1056
Tenure	-0.58509 <.0001	-0.55395 <.0001	-0.10341 0.0009	1	-0.63298 <.0001	-0.63617 <.0001	-0.56199 <.0001	-0.36207 <.0001	0.16846 <.0001	0.0361 0.2478	-0.38069 <.0001	-0.30163 <.0001	-0.20232 <.0001	-0.4165 <.0001	0.02097 0.5021	0.59313 <.0001	-0.47652 <.0001	-0.50393 <.0001	-0.17835 <.0001
Vacant	0.83819 <.0001	0.82145 <.0001	0.57434 <.0001	-0.63298 <.0001	1	0.8557 <.0001	0.62535 <.0001	0.57329 <.0001	-0.03921 0.2093	-0.08262 0.0081	0.44683 <.0001	0.28803 <.0001	0.16699 <.0001	0.45313 <.0001	-0.09874 0.0015	-0.42091 <.0001	0.51461 <.0001	0.34508 <.0001	0.10054 0.0013
Nuisances	0.95063 <.0001	0.9603 <.0001	0.7529 <.0001	-0.63617 <.0001	0.8557 <.0001	1	0.78918 <.0001	0.55183 <.0001	0.00533 0.8645	-0.04932 0.1142	0.46886 <.0001	0.30586 <.0001	0.19684 <.0001	0.49852 <.0001	-0.07751 0.013	-0.39396 <.0001	0.43522 <.0001	0.34627 <.0001	0.00689 0.8255
Crime	0.6721 <.0001	0.77812 <.0001	0.56551 <.0001	-0.56199 <.0001	0.62535 <.0001	0.78918 <.0001	1	0.30346 <.0001	-0.05692 0.0682	0.0611 0.0503	0.37447 <.0001	0.26744 <.0001	0.18109 <.0001	0.41334 <.0001	0.0079 0.8003	-0.36219 <.0001	0.4097 <.0001	0.29076 <.0001	0.21387 <.0001
Amenities	0.55942 <.0001	0.45229 <.0001	0.42394 <.0001	-0.36207 <.0001	0.57329 <.0001	0.55183 <.0001	0.30346 <.0001	1	0.00172 0.9561	-0.05237 0.0935	0.32353 <.0001	0.23798 <.0001	0.0514 0.0997	0.3176 <.0001	-0.03662 0.2409	-0.27955 <.0001	0.25328 <.0001	0.25826 <.0001	-0.04138 0.1851

Table 6: Pearson's Correlation Coefficient's between Secondarily Adjacent Blocks and Demographic Variables

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