A Time-Series Analysis of Building Footprint Data in a Shrinking City

A thesis submitted by

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Abstract

This thesis uses the building footprint data in a typical shrinking city, Baltimore, in 1972 and 2010 to achieve two prime research objectives. The first is to understand the historical patterns of housing construction and demolition in row house neighborhoods in Baltimore. And the second is to figure out the building footprint changes from 1972 to 2010, and the relationships between the change and some socioeconomic and physical factors. The conclusion is that the study area of five row house neighborhoods has experienced housing loss, but the conditions are different between the five neighborhoods. The housing loss is more likely to happen in areas with certain socioeconomic and physical characteristics, which can be explained by the unique construction and block patterns of row houses. On the basis of the research conclusion, the thesis came up with four policy recommendations for the City of Baltimore as the row house redevelopment strategies.

Acknowledgements

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Chapter 1: Introduction

In many nations around the world, cities are losing population and housing stock (Martinez-Fernandez et al., 2012). During the latter half of the 20th century, there are 370 cities worldwide with more than 100,000 residents witnessing the population decline of at least 10 percent (Hollander, 2010). At the same time, with those people moving out, these cities also face challenges of abandoned housing, vacant lots, depressed markets, malfunctioning infrastructure, and deteriorated neighborhood environment (Haase et al., 2010; Hollander, 2010; Schetke and Haase, 2008). While many planning scholars and practitioners focus on addressing the problem of how to reuse the abandoned houses and vacant properties to reverse this shrinking trend or to let these cities shrink in a healthy way (Großmann, 2013; Blanco et al.), one important research question we need to consider is how the demographic, social, economic and built-environmental factors are related with the declining neighborhoods in shrinking cities. Using these factors, planners can actively predict and respond to urban shrinkage. Furthermore, they can improve those areas accordingly to prevent the abandonment or vacancy in the beginning.

Baltimore is a typical example of shrinking cities. Since the 1950s, Baltimore has been severely losing its population and housing stock. The city's population reported in the 2010 census suggests a 31.5% decline since 1970. Based on Cohen's research, from 1950 to 2000, the number of abandoned housing units in the city can be as large as 42,480 (Cohen, 2001). Sustained economic and social decline has already left the city with ongoing outmigration, increasing housing vacancy, endless demolishment and poor-quality infrastructure (Cohen, 2001; Schoenbaum, 2002). The unique landscape of row house neighborhoods in Baltimore differentiates it from other low-density shrinking cities. Apart from social and economic researches, a thorough investigation of the building environment in Baltimore is needed to better understand the shrinkage in high-density neighborhoods.

This thesis looked closely into a study area of five row house neighborhoods in East Baltimore. From a building footprint perspective, this thesis explored two prime research questions:

1) What are the historical patterns of housing construction and demolition in row house neighborhoods in Baltimore?

2) How have row house building footprints in the five neighborhoods changed since the 1970s, and how are some of the demographic, social, economic, physical and building-environment factors related to the changes?

a) How did the row house building footprint change from 1972 to 2010?

b) What are the relationships between the row house abandonment and economic, demographic, locational, and architectural factors?

c) How can the above factors be used in predicting the row house building footprint change and urban shrinkage?

There was further discussion about the implications of these results for local community development. As the City of Baltimore is working on the "Vacants To Value" program to solve problems of persistent disinvestment, population decline, and reduction in habitable housing stock in row house neighborhoods, this research can be of practical meaning to Baltimore's planning practitioners and policy makers. It can also provide some experiential guidelines for other shrinking cities with row houses or of high density, like Philadelphia.

Chapter 2: Literature Review

2.1 Shrinking Cities

There hasn't been a consensus on the definition of the shrinking city. The Shrinking Cities International Research Network (SCIRN) defines a shrinking city as "a densely populated urban area with a minimum population of 10,000 residents that has faced population losses in large parts for more than two years and is undergoing economic transformations with some symptoms of a structural crisis" (Wiechmann, 2008; Hollander, et al. 2009). Even though reasons of the shrinkage vary in different cases, shirking cities are typically caused by a combination of deindustrialization, suburbanization, and/or demographic shifts. Meanwhile, they face problems of population decline, housing vacancy, employment loss or neighborhood quality decrease as well. (Hollander et al., 2009; Martinez-Fernandez et al., 2012).

From 1970 to 2010, the population of Baltimore constantly dropped from 906,244 to 621,210 (Figure 1). Based on SCIRN's definition, Baltimore is a typical shrinking city.

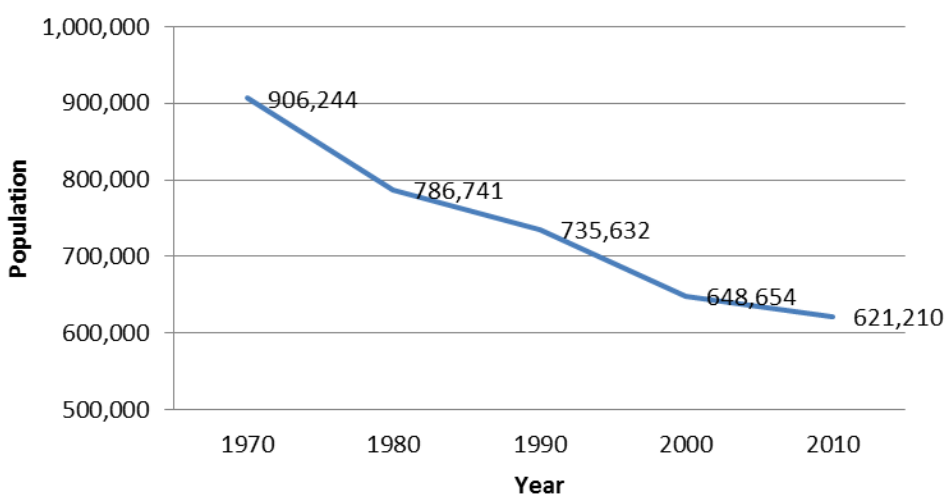


Figure 1. Census Population of Baltimore from 1970 to 2010
(Data of 1970 to 2010 Census form Social Explorer. Retrieved from http://www.socialexplorer.com/)

2.2 Measurement of Shrinkage

In planning literatures, different measurement methods are used to measure the urban shrinkage. Population loss is one commonly used measurement. Some articles interested in the housing look into the change of housing stock, which is one of the most widely discussed topics in the planning field. There are also studies utilizing the house abandonment or house vacancy as a practical variable presenting the degree of how abandoned or vacant the city is. In different literatures, however, the concrete measurement methods of house abandonment and house vacancy are different.

Many literatures use the vacancy data from census data (Hollander, 2010). This method is easy to get data and is nationally applicable. Census Bureau defines a housing unit as vacant "if no one is living in it at the time of the interview, unless its occupants are only temporarily absent" (United States Census Bureau, 2014). Under this definition, the house is vacant excluding that it is newly built but not sold, or it is to be demolished or is condemned, or its outside constructions are so destroyed that they cannot protect the interior. This measurement cannot fully reflect the physical change and influence of the housing decline, since the demolished houses that can have strong influences on built environment are not taken into account. Another limitation of the measurement is that they cannot represent the change of each house because census data are aggregated in groups like the census tract. What's more, the change of census tracts can lead to mistakes in time series analysis (Hollander et al., 2010).

Another method is to use the United States Postal Service (USPS) vacancy address database (Silverman et al., 2006; Hollander, 2010). The USPS data lists how many housing units received mail during a given month in each zip code. After a housing unit is emptied of occupants and with no one receiving mail at the location, it is considered vacant. After 90 days of vacancy, the USPS no longer lists the unit as active and removes it from the occupied housing unit list. To protect the residents' privacy, USPS only published an aggregated database at the census tract level, which also makes the analysis of housing at micro level impossible.

Housing demolition is a popular method in researches as well. Demolition measurement is usually based on the address list offered by the local planning departments. Then the address data are geocoded in the GIS software. Frazier did the demolition mapping at the block group level, and examined the association between demolitions and crimes through a comparative statistical analysis (2013). Farfel analyzed the environmental influence of demolition with GIS tools (Farfel et al., 2005).

Other measurements of shrinkage are different from each other based on the research interests, the data accessibility and concrete condition of the study areas, like using the scale of housing abandonment which is scored by local residents and planners through the interview (Morckel, 2013).

2.3 Baltimore Row House Neighborhood

In Baltimore, the row house has a long history. For more than one hundred fifty years, the row houses symbolized homeownership and stability for Baltimore's working and middle class (Hayward et al., 1999). During years of constructions and development, they've evolved into different types, offering Baltimore residents places to live and building the landscape of the city (Hayward et al., 1999).

Since the nineteenth century, the row house derived from the British building form has become the dominant house type of the city (Hayward et al., 1999). Nowhere else in America has seen bigger amount and longer persistence of row houses than Baltimore. These rows of attached houses were the main form of urban housing in the 1800s (Langdon, 2001).

In the 19th century, prosperous people tended to live in high-ceilinged, three-story row houses, which were often built along main streets or looking onto parks. People with little money inhabited tiny row houses – shallow, lower-ceilinged, two-story dwellings. Since they were usually built along alleys behind the larger houses, those small row houses are also called alley houses. Some of those 19th-century dwellings, particularly on the alleys, were just 10 to 12 feet wide (Hayward et al., 1999).

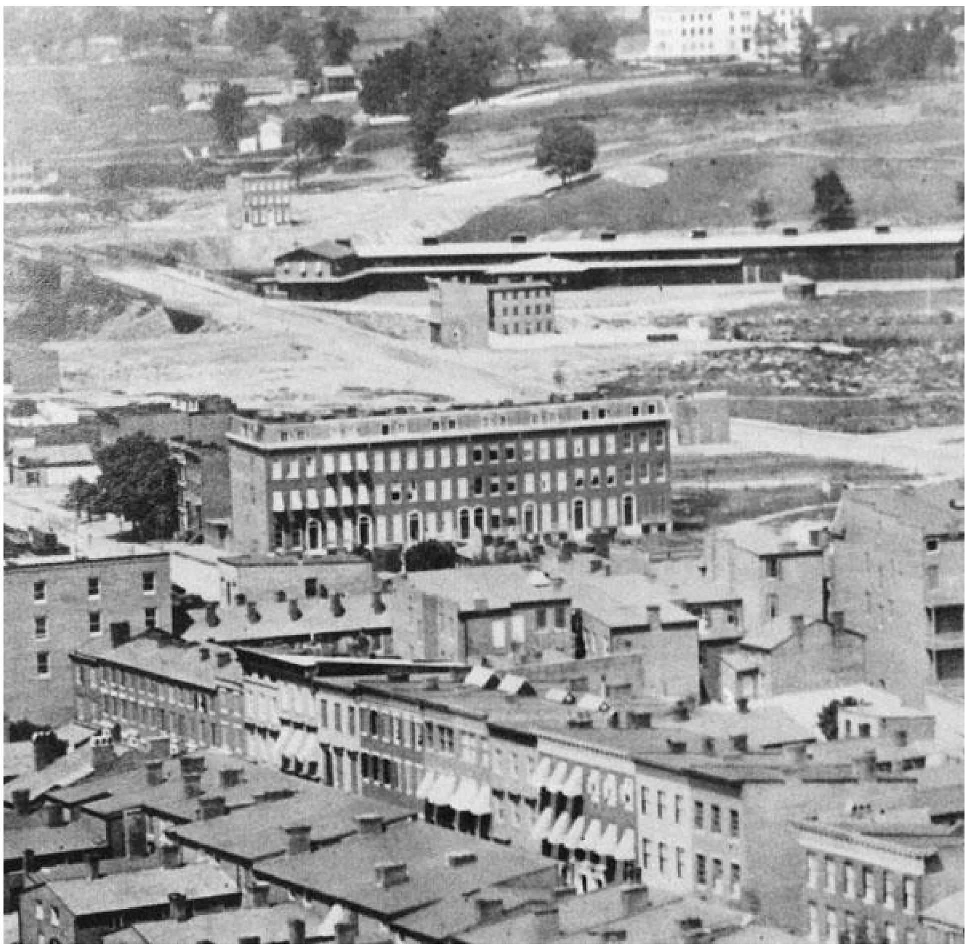


Figure 2. Historical Photo of Baltimore Row House in 1874
(Taken by Baltimore photographer William H. Weaver, 1874)

Between the Civil War and the World War I, Baltimore went through rapid industrialization. Factories sprang up like mushrooms; roads, ports and rail system extended accessibility; jobs emerged everywhere in the city. Speculatively built row houses provided houses that modestly paid workers could afford. Those row house neighborhoods were within the walking distance to those blue collars' working places and necessary facilities. The row house form was compact enough to form a really high-density community to accommodate a broad spectrum of economic classes (Hayward et al., 1999; Langdon, 2001). During this period, the housing market was dominated by some prime developers, and row houses were built in massive amount at one time (Hayward et al., 1999). While the massive development brought down the project costs, the forms and styles of row houses evolved. Some were built with undulating facades or with bay windows that punctuated the street and brought extra light into the second floor. Whereas old row houses had their doors and windows up against the sidewalk, some of the newer homes featured front porches.

After World War II, Baltimore sadly experienced the breaking down of the intimate mixing of workplaces and housing (Hayward et al., 1999). Urban manufacturing suffered a huge decline. The disappearance of industrial jobs has aggravated the deterioration of the residential areas nearby. In the past dozen years, thousands of jobs at plants were lost, leaving the Baltimore waterfront vanished. Residents moved out of the high-density and walkable row house neighborhoods. Instead, they gravitated to vehicle-oriented development suburb away from central cities, where tract houses were built and new job opportunities were offered. Gradually, detached houses and automobile-reliant suburbanization became the new form (Hayward et al., 1999). As more and more residents moved out, neighborhoods became poorer; crime-ridden; and bereft of legitimate jobs, many houses have been sold to absentee landlords or have deteriorated after their elderly owners died (Langdon, 2001). Landlords have milked their properties and abandoned them when they turned unprofitable. Some unoccupied houses have been stripped or used for illegal activities. With their doors and windows covered by plywood, chipboard, or sheet metal or left open to the elements, derelict houses have given their neighborhoods a shabby appearance, exacerbating the demoralization (Langdon, 2001).

2.4 Socioeconomic Factors Related to Shrinkage

Urban shrinkage is a multidimensional process that relates to multiple factors (Fol, 2012). Literatures have explored the factors interacted with the housing decline. And most of them are demographic, social and economic related.

Population

Population loss is often associated with house abandonment and city shrinkage. The amount of residents in the neighborhood determines the amount of housing required in the local market (Mallach, 2006; Morckel, 2013). More residents mean the more housing requirements and the more active housing market. However, if the residents move out, the once occupied house would become unoccupied or abandoned. This would result in the decline of the local housing market and the municipal revenue. All the above reactions of the population and housing loss would work on the remaining residents, forcing them to move out and causing more population and housing loss (Berkovec, 1996).

Race

Literatures of segregation since the 1950s' have shown that residents' racial condition is related to the neighborhood decline and housing abandonment (Massey, 1990). A study by the National Fair Housing Alliance (2012) found that REO (also known as real estate- or bank-owned) properties in white neighborhoods are much better maintained and marketed than REO properties in minority neighborhoods. As a result, foreclosed properties in minority neighborhoods are more likely to face long-term vacancy and demolition (National Fair Housing Alliance, 2012).

Income

The living condition is determined by the income (Bassett et al., 2006). A stable income is the cornerstone to maintain and improve residents' housing conditions. The cutting down of the income usually means the inability of paying mortgage to the American families (Mallach, 2006).

Employment

Even though the mobility of the Americans has been improved so much with the spread of the interstate highway and the blooming of the aircraft industries, still, we live where we work. So employment is another important factor influence residents' socioeconomic status as well as neighborhoods' housing vacancy (Mueller and Parcel, 1981). So when the local label market decline, residents would naturally move away to other places where more jobs can be offered. Then the houses left would be kept unoccupied or abandoned.

2.5 Building Environment

Unlike many works done to look into demographic, social and economic elements related to housing abandonment, the literatures studying how physical factors are related to housing change, especially the ones using empirical evidence to demonstrate that, is limited.

Density

The urban density is a useful tool for planners to control the land use, urban form and community development (Mills, 1970). With more than four decades of sprawling of American cities, the high density urban form area now draining more attention since it is firmly related to many planning strategies like transit oriented development (TOD), mixed use and green city (Dunphy and Fisher, 1996; Steemers, 2003). Many studies have viewed the high density as a positive factor for the renewals. A study of the 10 biggest American cities has shown that the high-density areas are the most vibrant with their low-density compels (Ryan, 2012). Meanwhile, high-density housing neighborhoods, like the row house neighborhoods in Baltimore, have different renewal environment compared with the sprawling suburban area of American cities. But some different opinions pointed out that high-density can be the obstacle to redevelopment.

Changes in Neighborhood

It's widely believed that declines in the neighborhood have great influence on the surrounding housing. The traditional theory like Broken Window Theory has declared that (Fagan and Davies, 2000). In the decline neighborhoods, this can be seen as the cluster of vacant or abandoned houses. A survey of 99 cities found that two thirds of the samples (99 cities) having vacant and abandoned properties in specific neighborhoods or areas rather than scattered throughout the city (Accordino and Johnson, 2000). Other studies also acknowledged that there are statistically significant hot spots or clusters of abandonment, and while planners predict housing abandonment, taking the spatial relationships can significantly improve the accuracy then just considering socioeconomic factors (Hillier et al., 2014).

Green Space

Green space within the walking distance can encourage residents to walk and exercise, gather together and communicate with each other (Maas et al., 2006). It's widely accepted that green space is contributive to residents' physical and mental health. It is also a big improvement in the housing built environment at the aesthetic perspective. Moreover, green space can lead to a higher housing value (Cho et al., 2006). It is also believed to be an effective way to improve the appearance of the vacant lots in the decline neighborhoods. Many neighborhoods with the vacancy problem are actively redeveloping lots into green spaces (Langdon, 2001).

Location in neighborhood

Row house neighborhoods have its special character that the adjacent houses share the same wall. The demolition of one row house can affect the houses next to it. If the house at the end of the row is demolished, only one wall shared with the next door house is needed to deal with. While the house in the middle of the row has two walls to deal with, this means double cost. What's more, the vacant lot between two houses is much more obvious than the vacant lot at the end of the row.

Most of the literatures just look at one or two factors. But the study of Morckel (2013) combined a group of factors from different perspectives together to see if they can form a simple construct to represent abandoned housing. There were 15 variables to form four constructs, housing market condition, physical neglect, socioeconomic condition, and financial neglect. The variables include population, residents' age, property are, education, poverty and so on. The factor analysis proves that at least 15 variables have been shown to relate to abandonment. This study can help both the academic and the professional to better understand and predict the house abandonment.

Chapter 3: Methods and Data

This thesis studied five row house neighborhoods in East Baltimore. The five row house neighborhoods are Better Waverly, Broadway East, Coldstream Homestead Montebello, East Baltimore Midway and Oliver. These neighborhoods were selected as a follow-up to the Baltimore Vacant Lot Redevelopment Project completed by Michael Johnson and Justin Hollander in 2013 (Johnson and Hollander, 2014).

This thesis analyzed how the building footprint change in the five neighborhoods relates to the nine factors below via both qualitative and quantitative methods. These nine factors were chosen on the basis of existing literature and my research focus. Apart from the four traditional socioeconomic factors, I also added in five physical factors. For the four socioeconomic factors, including population, racial composition, unemployment, poverty, this thesis did the qualitative data analysis. For the five physical factors, including the density of surrounding area, building footprint change in surrounding area, location in block and green space accessibility, this thesis not only described the data, but also used chi-square test in SPSS to see if these five factors are statistically correlated with the housing changes. The historical high-resolution image of the study area, vector data of current building footprint, census data, together with the land use data was used and analyzed in the GIS platform ArcMap to illuminate and explain the nine factors.

3.1 Building Footprint Data

Maps and sketches of building footprint have been the useful information for centuries all around the world. For example, Sanborn maps in the US have been produced for American cities since the mid-19th Century (Laycock et al., 2011). Traditionally, building footprint data are widely used for civil engineering, fire insurance and urban design (Wang et al., 2006; Shapira et al., 1996; Johnson, 2008). Nowadays, with the growing concern about how urban construction interacts with the ecosystem, and how the building scale influences building energy efficiency, building footprint data are becoming important data for ecosystem studies and green building and neighborhood design. In the Leadership in Energy & Environmental Design (LEED) certification, building footprint data are very important to calculate the rating of the building and neighborhood.

Another fact facilitating the usage of building footprint data is the development of computer science and picture processing. GIS literature showed that there are abundant achievements in landscape change analysis using image data (e.g., Ellis et al., 2006). Different kinds of data were used, and the quality of the raw data determined the resolution of final results. For example, one typical method is interpreting the high-resolution images, which includes current remote sensing data and historical aerial photos, into different land type, and then analyzing the data change in each pixel through the overlaying of different layers (Ellis et al., 2006). More and more historical data can be transported into high-resolution data so that they can be analyzed in the GIS platform to help better understand the spatial pattern of our cities.

Building footprint data can show not only how human-dominated process that has lasting impacts on biodiversity and ecosystem processes, but also how the historical towns and cities have changed over time (Laycock, 2011). Since urbanization is the most important human-dominated process that has lasting impacts on biodiversity and ecosystem processes, most of the past studies focus on the expansion of urban construction and how this process affect land use, natural environment and even global climate. The other trend of urban shrinkage, however, hasn't fully used these data. In this thesis, the historical and newest building footprint data were used to see how these data can be used for the urban studies.

3.2 Extraction of Row House Building Footprint Changes

The data I used were Baltimore City's historical image data of 1972 and the current vector building footprint data of 2010. The 1972 data are from the high-resolution aerial photographic maps of Baltimore City. The primary photos were taken during a flight on March 26, 1972, produced for the Baltimore City Planning Department by Maps Incorporation. JScholarship at Johns Hopkins University scanned the hard copy of the map, and created the digital edition as JPEG files in the fall of 2011. The data were published online for free[1]. The 2010 building footprint data were from the vector layer of the detailed building footprint in 2008 published online for free by the City of Baltimore[2]. I updated the data with reference to the Google Earth image taken on August 29th, 2010.

Choosing the time point of 1972 is based on two reasons. The first is the data availability. The 1972 map is the best-quality historical map I can find. The plotting scale is as high as 1:4,800. Moreover, it can cover the whole study area. The other reason of choosing the 1972 map is the special development history of Baltimore row houses. As reviewed above, the beginning of the latter half of the 20th century is when the neighborhood structures were not severely changed. 1972 is the time point early enough to show the whole picture of how the Baltimore row house neighborhood was changed.

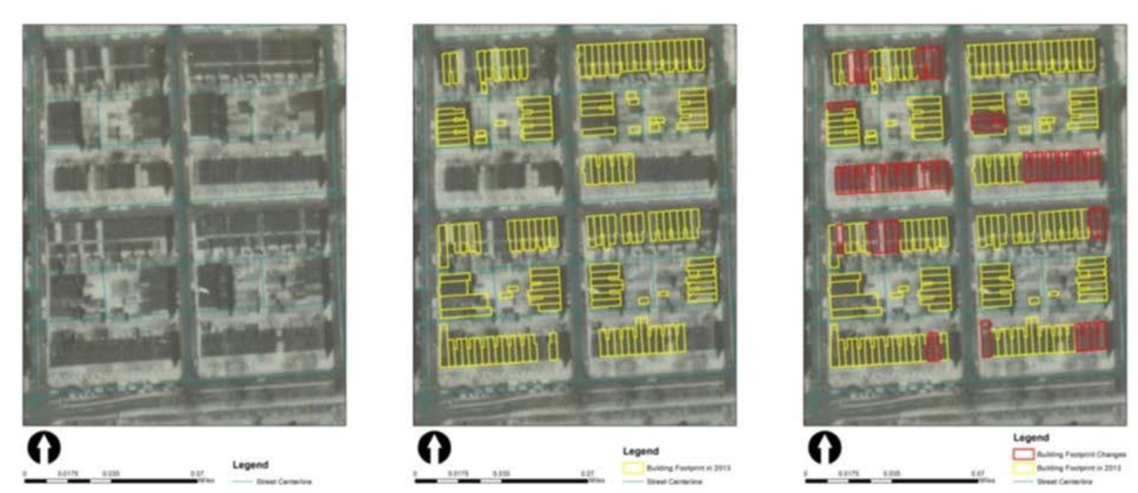
Data preparation and analysis were done in the GIS software ArcMap 10.0. The JPEG file of the 1972 map was first assigned with a reference system and then georeferenced to the building footprint layer. After overlaying the two data layers together, I compared the building footprints of the two time points and recorded the change data into a new point data layer. This new layer stored the change information by discrete data, with -1 as housing loss, representing that the original building footprint in 1972 is gone by 2010, 0 as standing structure, that the original building footprint in 1972 is still standing by 2010, and 1 as housing increase, representing a new building

[1] JScholarship at Johns Hopkins is a partnership between Johns Hopkins scholars and the Johns Hopkins Libraries. It consists collections of research outcomes produced by Johns Hopkins researchers, which are managed, preserved, and distributed by JH Libraries through JScholarship. The data used in this thesis can be retrieved from: https://jscholarship.library.jhu.edu/handle/1774.2/35334

[2] The data used in this thesis can be retrieved from: https://data.baltimorecity.gov/Geographic/Building-Footprint-Shape/deus-s85f

footprint added in 2010. Figure 3 shows the whole extraction process in a four-block pilot area and how data were stored in the new layer.

After I get the data of building footprint change, the analysis foci are the housing changing trend, changing amount, spatial distribution of the changes and different built-environmental characteristics of the changes.



Historical data in 1972 → Overlaying with data in 2010 → New change data

Figure 3. Example of the Extraction of Building Footprint Change

3.3 Descriptive Analysis

Data description and analysis were done for the four socioeconomic factors. This thesis not only showed the demographic, social and economic background of the study area, but also presented how the building footprint varied in the different socioeconomic backgrounds by overlaying the map of each factor and the building footprint together.

I did not use quantitative methods here for the following reasons. The inconsistence of data resolution level is the first one. The building footprint change is at the parcel level, while the socioeconomic data were at the census tract level. Secondly, the boundaries of the census tracts do not match with the neighborhood boundaries (Figure 4). Last but not the least, even if all the data are transformed into the neighborhood level, the quantitative analysis is not meaningful since there are only five samples in the study area.

Figure 4. The Census Tracts Covering the Five Neighborhoods

The socioeconomic data were from census data and the data of American Community Survey (ACS) in 1970 and 2010, all at the census tract level (For details, see Table 2). The population density factor was measured by the population density (person per acre) change between 1970 and 2010; the racial composition was measured by the African-American population percentage change between 1970 and 2010. The unemployment factor was measured by the unemployment rate change (percentage) between 1970 and 2010; and the poverty factor was measured by the percentage change of the family under poverty between 1970 and 2010.

3.4 Quantitative Analysis

Univariate analyses were used as the quantitative analysis method to see how physical factors are related with the building footprint change of row houses. Significance was determined using Fisher's exact chi-square. All statistics were calculated using SPSS for Windows. All the data were from the building footprint data mentioned above and the parcel data from the City of Baltimore through Professor Hollander's project. All the spatial data analyses were done in ArcGIS 10.0.

The density of surrounding area is measured by the1972 housing density of the150-foot buffer area around the house (housing count per acre, see Figure 5). The building footprint data were used. The calculation process was done in ArcGIS as the following. (1) Create a 150-feet buffer area around each point of building footprint; (2) Use the "spatial join" tool to get the building footprint amount within the buffer area; (3) Divide the housing number by the size of the buffer area. The data can better reveal the density condition than using the census data or other methods.

Figure 5. Calculation of Density in Surrounding Area

The housing change in surrounding area is measured in a similar way as the density of surrounding area. It's the housing loss (from 1972 to 2010) number within the150-foot buffer area around the house (housing count). Similar to the housing density calculation, this data processing was also accomplished in ArcGIS by the "spatial join" tool.

The green space factor was measured by the time (minute) it takes to walk from each house to the nearest green space. Data used here include the building footprint change data, the land use data of the City of Baltimore through Professor Hollander's project, and the road centerline data from the City of Baltimore open data website. In ArcMap, the cost weighed distance was calculated to estimate the shortest walking time from each point to the nearest green space (Liu et al., 2008).

The location in row factor was measured by whether the house is at the two ends of the row or not. If it's at the end of the row, the building footprint is set as 1. Otherwise, the building footprint is set as 0. This is done during the extraction of the building footprint change (Section 3.1).

The Alley House or not factor was measured by whether the row house is of regular size and along the neighborhood roads, or it is narrower, of smaller size and along the small alley. If it's all house, , the building footprint is set as 1. Otherwise, the building footprint is set as 0. Similar to the location in row factor, this is also done during the extraction of the building footprint change (Section 3.1).

After the pretreatment of all the above data (see also Table 1 for the details), this thesis set the building footprint change as dependent variable and the five factors as independent variables, and conducted the tabulation chi-square test to look into the relationship between the building footprint change and the five factors in a quantitative way.

Table 1

Dependent and Independent Variables in the Analysis

	Variable names	Measurement	Variable Type	Source
Dependent Variable	Building Footprint change	At the parcel level	Binary variables	Extraction of current and historical footprint data
Socioeconomic Factors	Population	Population change between 1970 and 2010 at the census tract	Continuous Variable	1970 and 2010 Census Data from Social Factors; 2010 Census tracts shapefile data from the Census Bureau
	Racial group	African American population percentage change between 1970 and 2010 the census tract	Continuous Variable	1970 and 2010 Census Data from Social Factors; 2010 Census tracts shapefile data from the Census Bureau
	Unemployment Rate	Unemployment rate change between 1970 and2010 at the census tract	Continuous Variable	1970 and 2010 Census Data from Social Factors; 2010 Census tracts shapefile data from the Census Bureau
	Poverty Rate	Family under poverty percentage change at the census tract	Continuous Variable	1970 and 2010 Census Data from Social Factors; 2010 Census tracts shapefile data from the Census Bureau
Physical Factors	Density of Surrounding Area	Housing footprint density at census block level	Continuous Variable	Building Footprint change date, census block shapefile data
	Housing Change in Surrounding Area	The amount of building footprint change within the 150 radius of each footprint point	Continuous Variable	Extraction of current and historical footprint data
	Green space	The time it costs from each change point to the green space	Continuous Variable	Building footprint change data, and the road centerline data
	Location in Row	Whether the house is in the middle of the row or at the end of the row	Binary variables	Building Footprint change date, the parcel data from the city of Baltimore through Professor Hollander's project
	Alley House	Whether the house is an alley house or not	Binary variables	Building Footprint change date; the parcel data from the city of Baltimore through Professor Hollander's project

Chapter 4: Results and Discussion

4.1 Overview of the Neighborhoods

The study area is composed of five row house neighborhoods, namely Better Waverly, Broadway East, Coldstream Homestead Montebello, East Baltimore Midway and Oliver (Figure 6). These five neighborhoods are located in East Baltimore where most of the constructions were done during the Civil War to house workers in the city's manufacturing, port, and railroad facilities (Cohen, 2001).

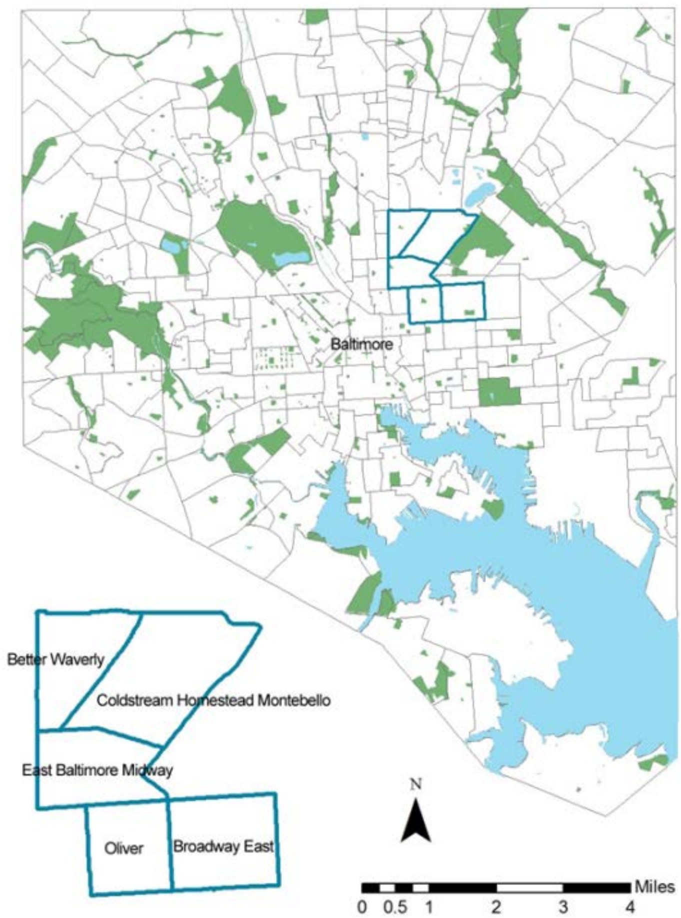


Figure 6. The Study Area of Five Neighborhoods in Baltimore

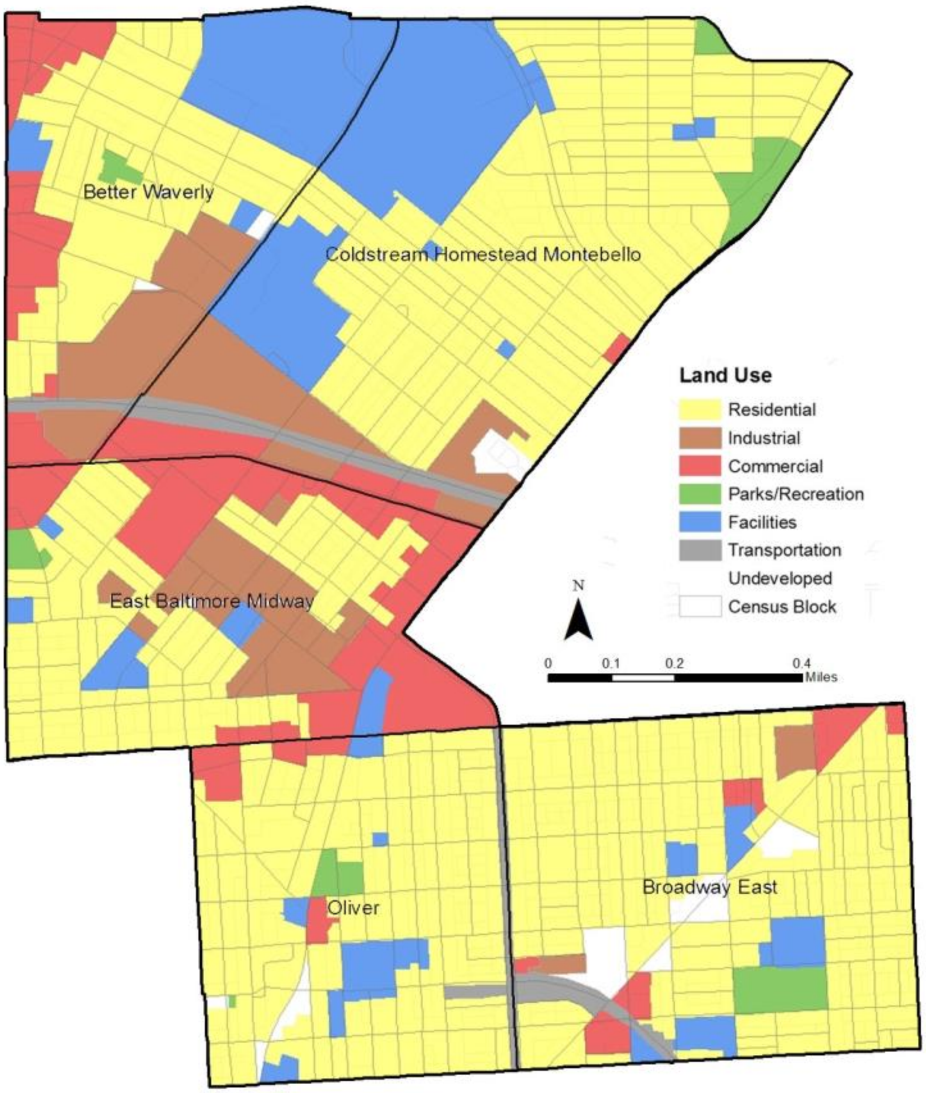


Figure 7. Land Use of the Study Area

Figure 7 shows the five neighborhoods' land use of 2008. Within the 1092-acre area, residential land use is the dominant, occupying more than half of the whole area. There are also remains of previous industrial land, from which we can still imagine how vibrant Baltimore was more than half a century ago. Commercial land is also an important component. It clustered along the rail track together with the industrial land, as the remaining urban pattern of a once booming industrial town. Even though the neighborhoods were designed as park-centered (Hayward et al., 1999; Cohen, 2001), the green space is still insufficient. Baltimore City College and Johns Hopkins

University Emerging Technologies Center are located in the northern part as the facilities land use area. To sum up, the five-neighborhood study area is a high-density, residential dominant, and multi-used area.

Figure 8. Street View in the Study Area
(Taken by Jingyu Tu, 2013)

Walking within the residential neighborhoods in the study area, you can see the two- or three-story brick-built row houses almost everywhere. Figure 8 is a photo of a representative street view of the study area that I took when I went there in Dec. 2013. These once tide and beautiful row house neighborhoods have changed accompanying the city's shrinkage. Many unoccupied row houses stood there demoralizingly with their doors and windows covered by plywood, chipboard or sheet metal, or left open to the elements. The derelict houses have given the neighborhoods an unsightly, "snaggle-tooth" appearance (Cohen, 2001). You can hardly relate this built environment to one of the most developed American cities in the 1940s with almost one-million population then.

4.2 Building Footprint Classification

A quick glance over the study area landscape would impress you with block after block of row houses with white marble steps. But if you zoom in and look closely at each row house, we can figure out the variations at once. A comparison between the building footprint of the five neighborhoods and Baltimore suburban area can demonstrate the difference between the two types of neighborhoods, as well as the different built environments among the five row house neighborhoods.

The building footprint in Oliver neighborhood is one typical row house block in the study area (Figure 9). Most of the row house blocks in Broadway East and Oliver, as well as some blocks in the south East Baltimore Midway are of this type. It's also the most condense row house block type in the five neighborhoods. Four rows form the outline of a square housing group. The houses in the rows are divided into two kinds facing two different perpendicular directions. These houses are right adjacent to the sidewalks or neighborhood streets, and don't have front yards. The space inside the block is also fully utilized. Two more rows of smaller houses were built there behind the row houses along the road. The average size of those houses is only about 10.5 feet by 50 feet, compared with the 15 feet by 75 feet row house along the street. Those simple and crude row houses are also called alley houses or crackerboxes in Baltimore. They were used to shelter workers with low income, and usually only two rooms deep. No roads are paved to reach the small-sized houses. While automobile cannot access those parcels, people can get to these houses via narrow alleys. Compared with the row houses along the street, they are miserable places to live in.

Figure 9. Oliver Building Footprint and Neighborhood Bird View

Those small alleys serving the rears of row houses are also a unique phenomenon in Baltimore (See the photo I took, Picture 10). Some alley can be as narrow as 10 feet, barely for a car to go through. These alleys are usually poorly paved. Those smaller ones in the back of regular row houses are gradually becoming the place for residents to drop rubbish or pile up castoff. They don't only harm the aesthetics of the neighborhood, but also are the breeding ground of crimes.

Figure 10. Alley behind Row Houses in East Baltimore Midway Neighborhood
(Taken by Jingyu Tu, 2013)

Another kind of row house block is less condensed and has better built environment. This type of row house block is composed of two parallel rows back to back. Each row is along the neighborhood street, with a wide alley, which can be 15 feet wide, between the two rows letting people go through. These row house parcels are longer than the ones in denser neighborhoods. Most of them can be as long as 100 feet, which offers sufficient space for both front and back yard. Usually, resident would use the space for lawn. Some of the houses are as narrow as a typical row house; Others can be as wide as 22 feet, almost twice the width of the row house in the first block patter (Figure 11). These wide ones are more like a small edition of the town houses, rather than the elongated shaped row house building footprint. This type of row houses is mainly located in Coldstream Homestead Montebello, Better Waverly and north East Baltimore Midway.

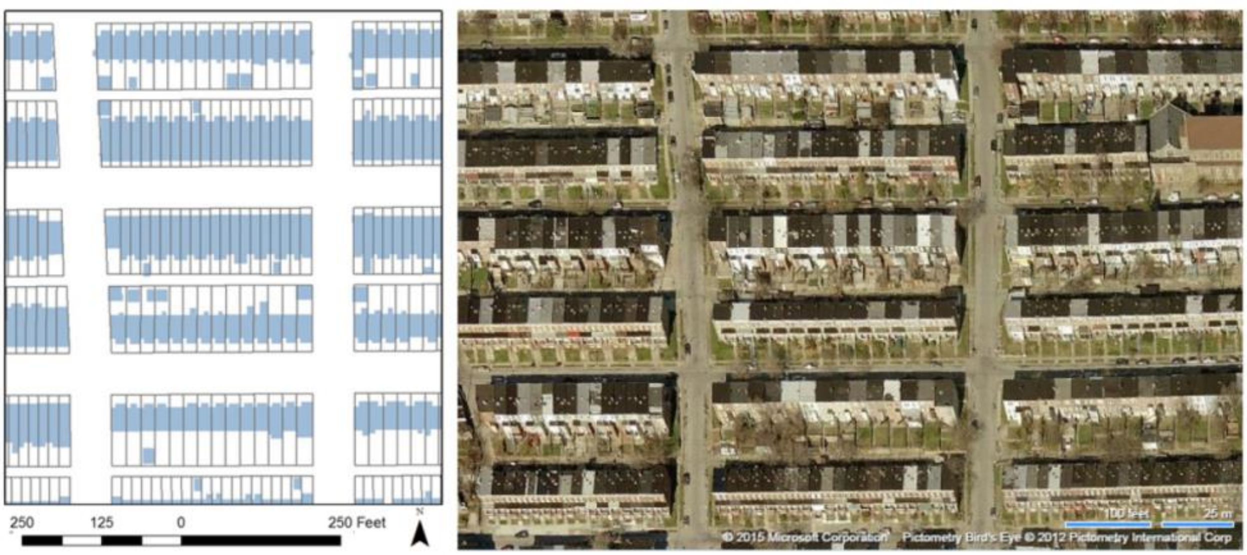


Figure 11. Coldstream Homestead Montebello Building Footprint and Neighborhood Bird View

In figure 12, we can see the typical suburban neighborhood in Baltimore. This residential area was built in the late 1920s. The blocks also come into the two rows back to back form. Two-lane roads lead to the front door of each house, while the small alley serving the rear. But as for the lot and housing sizes, this neighborhood is obviously different from the row house neighborhoods.

Houses built here are detached houses with their own yard and attached structure, located in parcels that can be as large as 50 feet by 110 feet.

Figure 12. Building Footprint of Baltimore Suburban Area and Neighborhood Bird View

4.3 Building Footprint Change

Table 2

Building Footprint Changes between 1970 and 2010

Neighborhood	Neighborhood Area (Acre)	Standing Structures	Footprint Loss	Percentage Change in Standing Structures, 1972-2010
Better Waverly	180.3	1,114	119	-9.81
Broadway East	221.7	3,198	**813**	-20.32
Coldstream Homestead Montebello	329.433	**3,261**	146	-4.34
East Baltimore Midway	191.9	1,502	211	-12.43
Oliver	168.3	2,214	560	-20.26
Sum		11,289	1,849	-14.07

The extraction of the footprint shows that there were in total 13,138 residential housing within the study area in 1972. Among them, 1,849 housing footprints changed afterward. All the changes are in the form that the original footprint of 1972 was gone, leaving the parcel empty. This changing trend of housing loss is consistent with the row house developing history discussed in the literature review. The building footprint loss in each parcel represents that the house has been demolished in the past 40 years. The total housing loss accounts for about 14.07% of the 1972 housing footprints.

The degrees of building footprint change in the five neighborhoods differ from each other (Table 2). Broadway East and Oliver suffer from the severest building footprint change; more than one-fifth of the 1972 row houses were gone. The two neighborhoods together account for about three-quarters of the total change within the study area; the Broadway East alone almost takes a half. Coldstream Homestead Montebello is the second largest neighborhood based on housing account, while it has the lowest footprint change percentage, namely 4.5%. The other two neighborhoods with lower housing units, Better Waverly and East Baltimore Midway, lost 9.81% and 12.43% of their original row houses respectively.

Figure 13 shows the distribution of building footprint change. The green points are the building footprints with no housing loss, while the orange points are the ones with housing loss. The blank is the non-residential land use area, which is not the research area of this thesis.

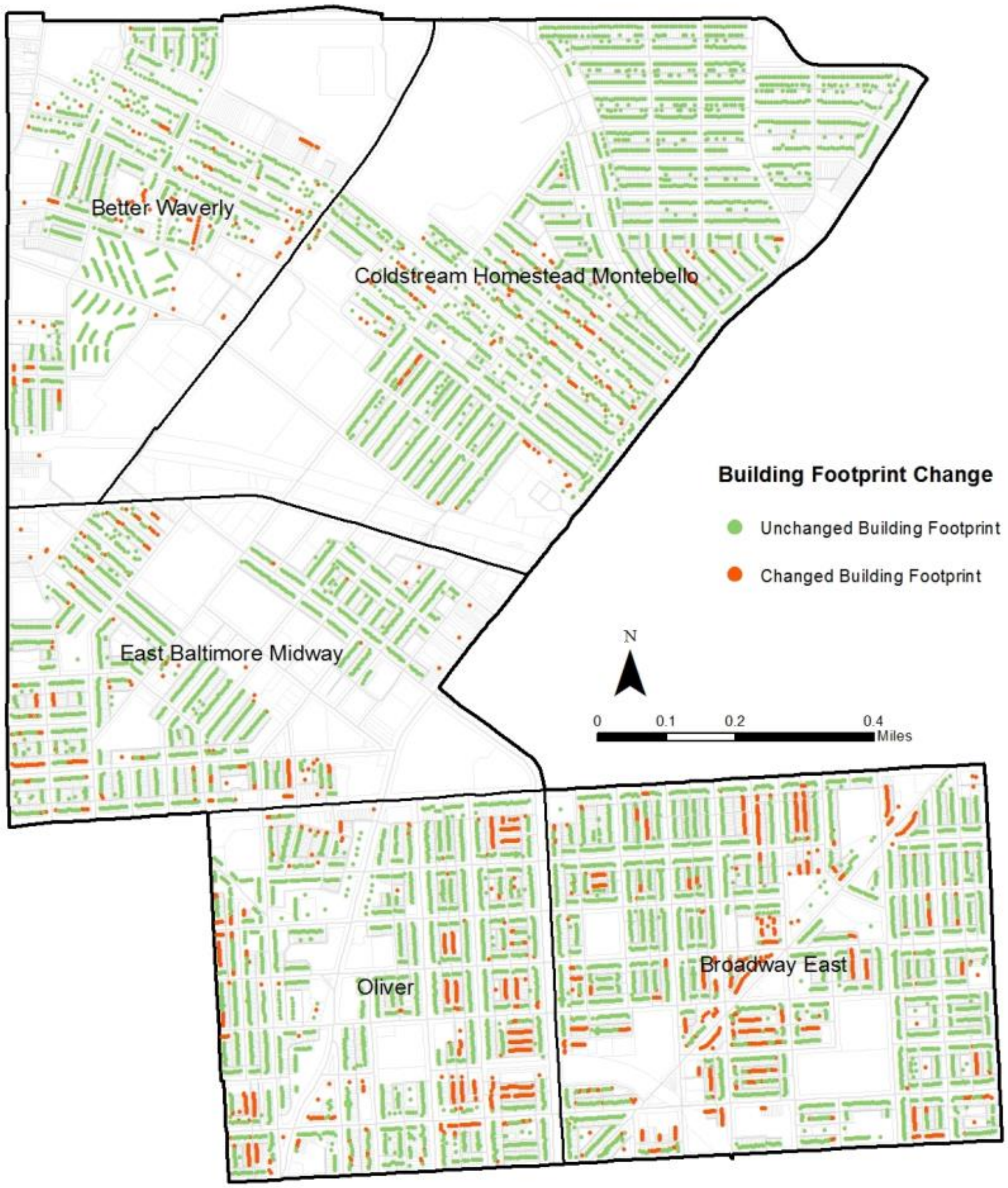


Figure 13. Building Footprint Changes

In Oliver, East Baltimore Midway and the southern part of East Baltimore Midway, where the row house blocks are filled with small and crude alley houses, the house loss came in the form of the whole row (e.g., Figure 14) rather than randomly scattered parcels. The building footprint loss is normally from alley houses of poor-quality. Many alley houses were demolished by row, but some were pulled down like the regular row house because of the housing quality. For the vacant lots left by demolition in these neighborhoods, many of them, especially the alley house parcels were redeveloped into parking lots for back yard parking. Others were renewed into small gardens of lawn and trees, with no fence and all exposed to the outside as a gap in the once tide row.

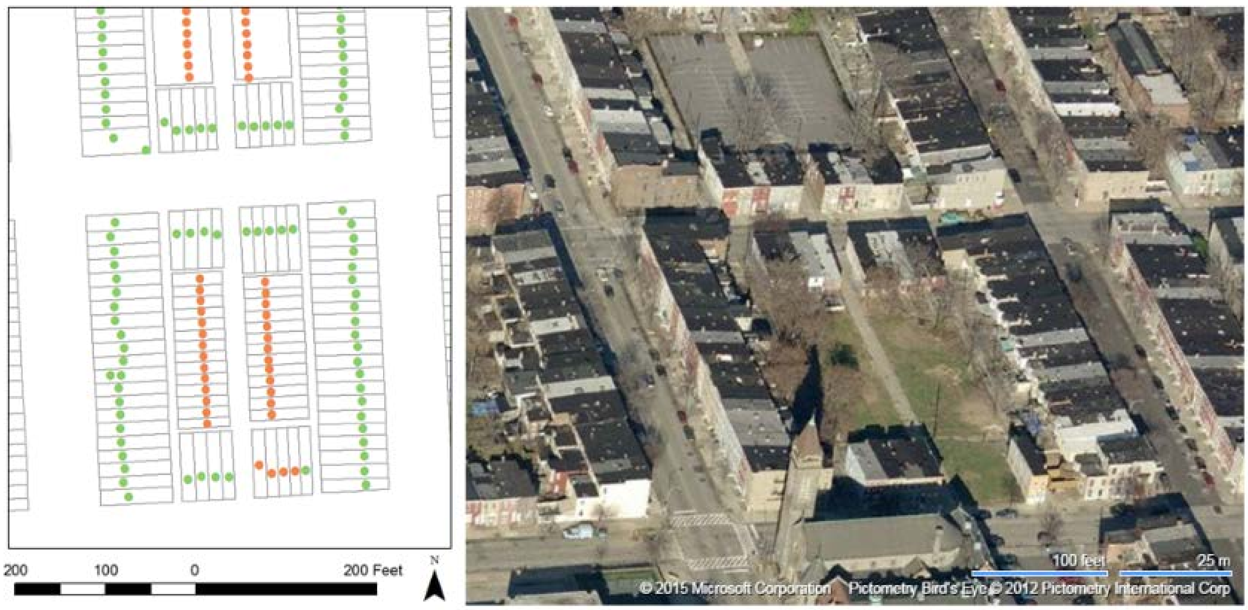


Figure 14. Oliver Building Footprint Changes and the Neighborhood Bird View

In Better Waverly, Coldstream Homestead Montebello and the northern part of East Baltimore Midway, the spatial distribution of the housing loss is relatively random (e.g., Figure 15). Since each row house in the block is of similar size, quality and location, there is no demolition of an entire row. The empty parcels are usually filled with lawn and trees. Some have fences around to prevent people coming in.

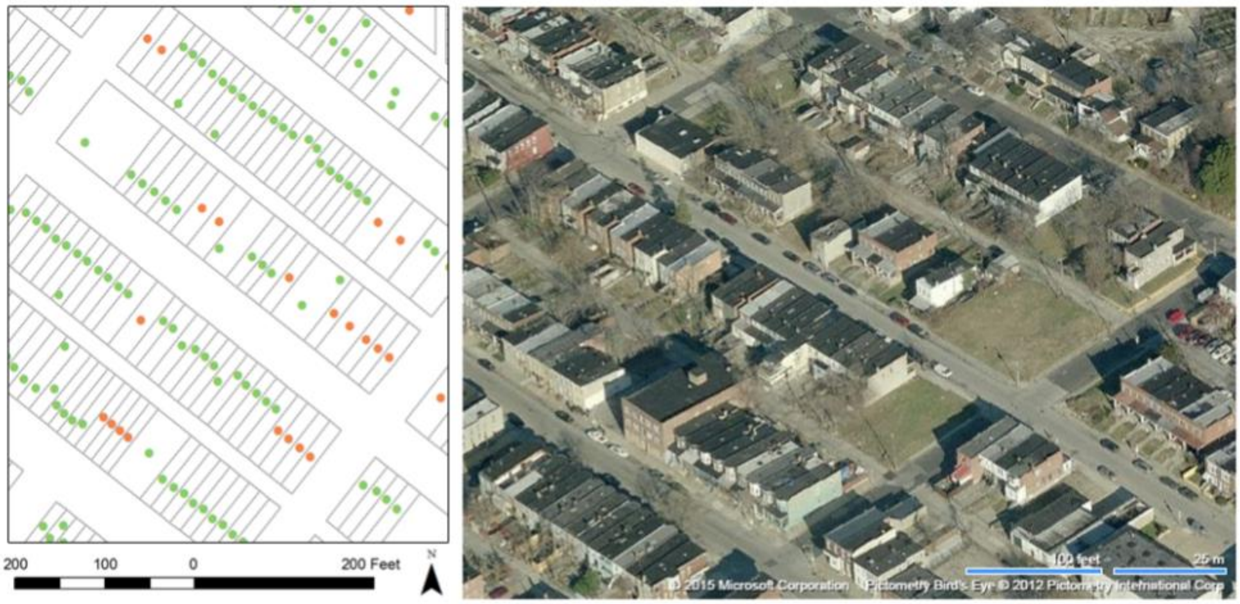


Figure 15. Coldstream Homestead Montebello Building Footprint Changes and the Neighborhood Bird View

4.4 Socioeconomic Factors

The study area has 13 census tracts (Figure 4). Table 3 shows how the five neighborhoods overlap with one to three census tracts. It also shows the socioeconomic data of the 13 census tracts in 1972 and 2010, and how they changed during the time period. For some census tracts, parts of which are in the study area, I assume they are homogenous, so the census data at the tract level can be used in the analysis.

Table 3

Covered Neighborhoods and Socioeconomic Data in 1970, 2010 and Changes between 1970 and 2010 by Census Tracts

Census Tract Number	Covered Neighborhoods	1970					2010					Percentage Change				
		Standing Structures	Population Density	African American Percentage	Unemployment Rate	Poverty Rate	Standing Structures	Population Density	African American Percentage	Unemployment Rate	Poverty Rate	Standing Structures	Population Density	African American Percentage	Unemployment Rate	Poverty Rate
802	Broadway East	826	29.90	96.6%	9.3%	24.3%	669	7.45	95.8%	6.9%	12.7%	-19.01	-75.08	-0.83	-25.81	-47.74
803.01	Broadway East	296	96.83	97.5%	7.2%	16.1%	257	31.40	97.5%	17.3%	18.7%	-13.18	-67.57	0.00	140.28	16.15
804	Broadway East	625	64.54	97.4%	8.2%	26.1%	536	25.22	94.8%	6.8%	26.9%	-14.24	-60.92	-2.67	-17.07	3.07
806	Broadway East, Oliver	1851	78.15	98.3%	5.2%	18.2%	1581	29.70	96.3%	10.6%	13.1%	-14.59	-62.00	-2.03	103.85	-28.02
807	Broadway East, Oliver	1370	70.22	99.7%	5.9%	21.0%	846	15.40	95.5%	7.5%	28.8%	-38.25	-78.07	-4.21	27.12	37.14
808	Broadway East, Oliver	359	56.26	99.5%	6.8%	36.1%	275	15.83	97.5%	9.9%	47.9%	-23.40	-71.86	-2.01	45.59	32.69
904	Better Waverly	747	28.08	23.3%	5.0%	35.7%	670	18.21	87.5%	11.7%	42.8%	-10.31	-35.15	275.54	134.00	19.89
905	Better Waverly, Coldstream Homestead Montebello	737	15.54	39.0%	3.8%	21.9%	671	10.72	82.6%	6.1%	22.1%	-8.96	-31.02	111.79	60.53	0.91
906	Coldstream Homestead Montebello	1469	65.09	83.7%	6.6%	10.7%	1449	34.46	95.5%	11.3%	13.5%	-1.36	-47.06	14.10	71.21	26.17
907	Coldstream Homestead Montebello	1687	58.57	92.6%	5.9%	16.0%	1589	29.15	96.5%	7.7%	25.1%	-5.81	-50.23	4.21	30.51	56.88
908	Better Waverly, Coldstream Homestead Montebello, East Baltimore Midway	1715	38.10	95.3%	5.4%	18.9%	1504	14.72	96.4%	6.1%	23.3%	-12.30	-61.36	1.15	12.96	23.28
909	Oliver	1211	37.16	97.9%	5.5%	35.0%	1052	14.44	96.3%	8.5%	42.1%	-13.13	-22.73	-1.6%	3.0%	7.1%
1001	Oliver	245	46.66	97.8%	5.9%	39.3%	190	18.96	96.4%	11.9%	19.9%	-13.13	-61.14	-1.63	54.55	20.29

Population Density

As we can see from Figure 16, the entire study area has the population density decline problem. The highest decrease is about 65 people per acre and the lowest loss is about five people per acre. For the parcels with housing loss, half of them (49.6%) are located in the four census tracts with the highest population density decline. Only one quarter (26.2%) parcels with no housing loss are in those four tracts.

At the spatial perspective (Figure 17), the high population density decline areas are in Oliver and Broadway East neighborhoods. About 90% of the two neighborhoods are residential land use. While in the northern part of the study area, namely the Better Waverly and Coldstream Homestead Montebello neighborhoods, population density did not decrease that much from 1970 to 2010. This can be partially explained by the mixed land use. In these two neighborhoods, residential land use is mixed with industrial, commercial and facility land use. Especially the two buildings of John Hopkins University and Baltimore College can help to attract and keep residents.

The most clustered building footprint changes are in the area with the greatest population density decrease, especially the row house blocks with alley houses demolished by row. The census tract where the population density changed from 97 to 32 people per acre had lost almost half of the housing amount in 1972. The row house blocks with two rows back-to-back, where the housing loss distribution is more random, are mainly in Better Waverly and Coldstream Homestead Montebello neighborhoods.

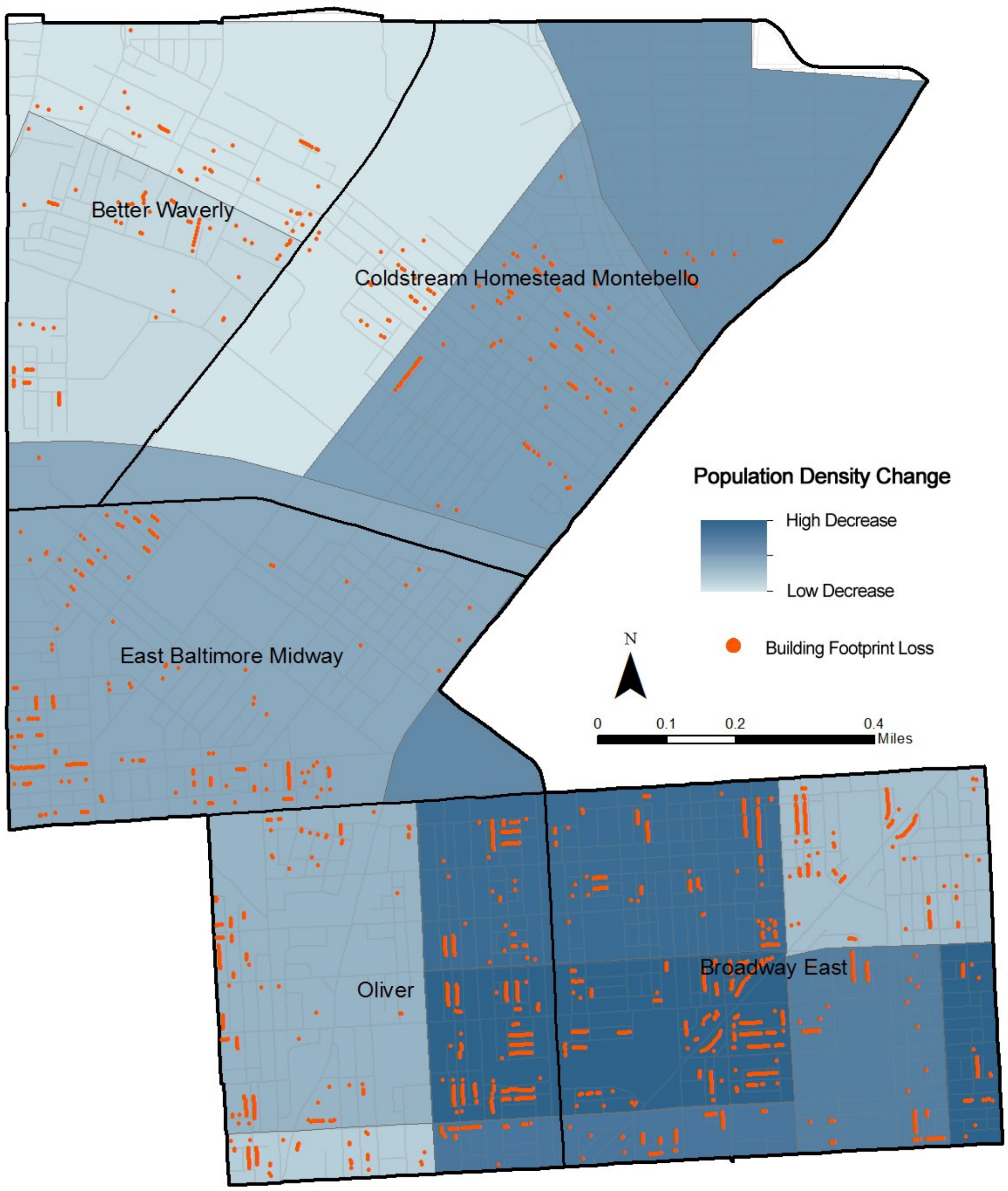


Figure 16. Population Density Change and Building Footprint Loss

Consistent with the summary in the literature review (Section 2.5), the housing loss is related to the population density loss. For a certain area, population density change represents the population change, and it is directly related to the demand for housing. The sharp decline of population density means a large amount of the original resident moving out, with few or no new residents filling in. The row houses which used to be suitable for the large population are left unoccupied. As time goes by, those unoccupied houses without care or renovation gradually lose their function and are inevitably demolished. In the high-density residential-use-dominant neighborhood like the study area, this correlation can be even stronger than other shrinking neighborhoods.

Racial composition

The African-American population percentage change of the study area varies between different census tracts (Figure 18). There is a decrease, no change, or an increase of the African American percentage in different census tracts. The change ranges from 4.2% decrease to 64.2% increase. 72.4% of the parcels with housing loss are in the African American percentage decrease area, while only 45.5% of the parcels with no housing loss are in the same area.

In the spatial perspective, the racial composition change is totally different from the population density change (Figure 19). The areas with the African American percentage decrease in Oliver and Broadway East are just where the population density severe declined. Meanwhile, Better Waverly and Coldstream Homestead Montebello with much less population density decline had an increasing African American percentage.

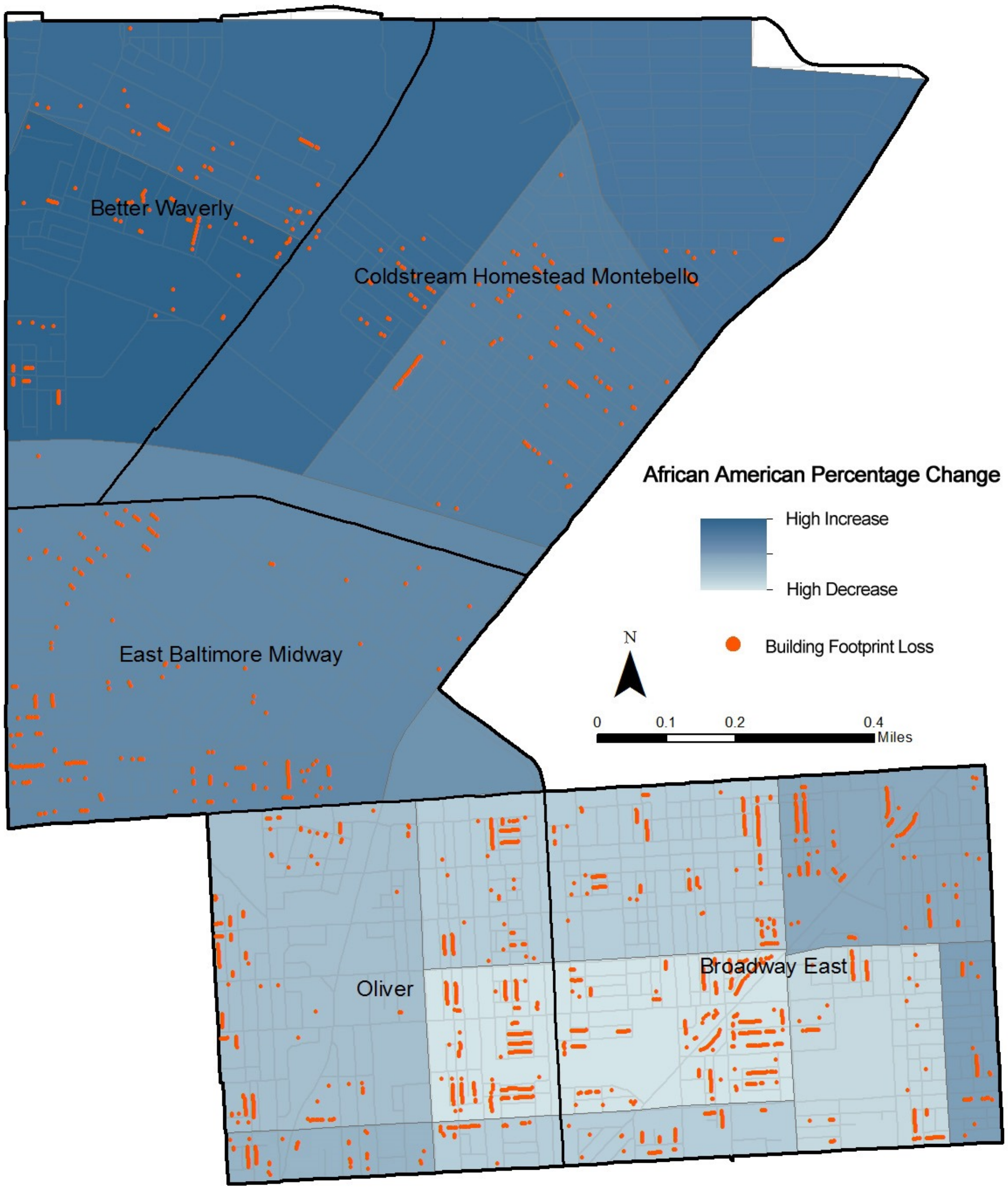


Figure 17. Racial Composition Changes and Building Footprint Loss

The housing distribution shows that most of the demolished row houses clustered in the high African American population percentage decrease area like Oliver and Broadway East. However, in the in neighborhoods like Better Waverly and Coldstream Homestead Montebello where housing loss more evenly distributed, the African American population percentage has grown from 1972 to 2010.

The above analysis shows that housing loss does have a correlation with the African American population percentage change in the study area. Existing studies have shown that abandonment occurs at higher rates in neighborhoods experiencing an influx of African American households. Despite the liberal attitudes of homeowners toward African Americans, white homeowners are concerned about declining housing prices when African Americans move in. Furthermore, a high percentage of African American residents have been believed to reduce the likelihood of whites buying a house in a neighborhood. This racial composition change can make it harder for the neighborhood to maintain and more likely to face long-term vacancy and demolition. However, in our case, the outcome of an opposite correlation can be explained in the following mechanism. The African American population percentage decrease areas have been minority neighborhoods since 1970. More than 90% of the residents in those neighborhoods were African American in 1970. In the past 40 years, the white population hasn't changed much. So the African American population percentage drop represents the huge loss of the African American population. That means that the total population declined dramatically, consistent with the conclusion from some studies that African American neighborhoods can experience a rapid population loss.

Unemployment Rate

In the study area, most census tracts' unemployment rate increased (Figure 20). For both the changed and unchanged building footprints, the largest part is located in the unemployment rate increase area.

As shown in Figure 21, the three unemployment rate decrease census tracts are in Broadway East neighborhood. East Baltimore Midway didn't have an increasing unemployment rate, but this rate also didn't decrease much compared with other neighborhoods like Oliver and parts of Better Waverly and Coldstream Homestead Montebello. Generally, the unemployment rate decrease areas are more likely to have housing loss, while the unemployment rate increase areas are more likely to have no housing loss.

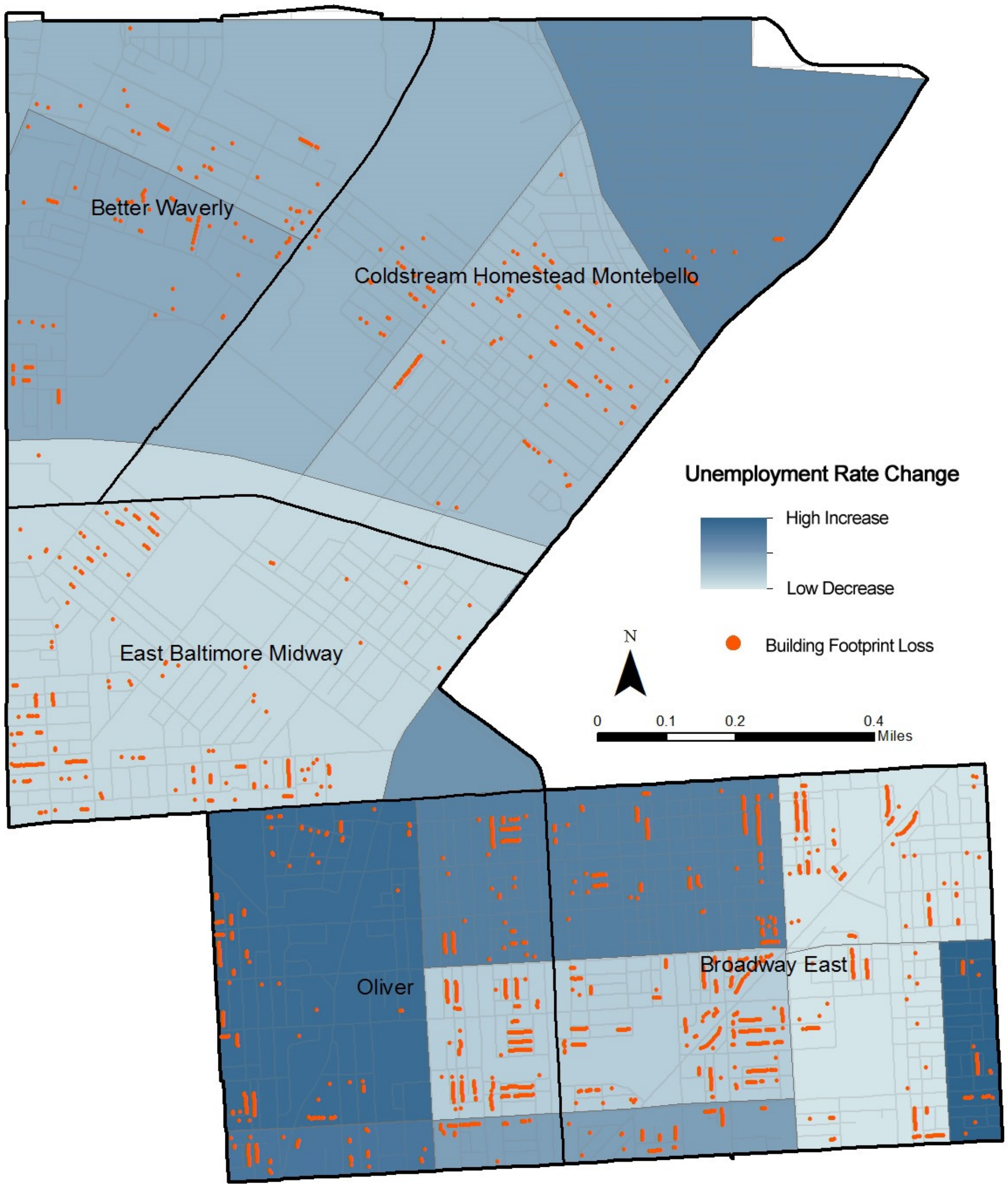


Figure 18. Income Level Changes and Building Footprint Loss

Even though the relationship between housing loss and unemployment rate is not as clear as the two factors discussed above, we can still say that more housing loss exists in unemployment rate decrease area in the five neighborhoods. However, many researches in other American cities have shown that the increasing unemployment rate can cause housing loss. A higher unemployment rate usually means worse economic condition. Residents are more likely to financially or physically abandon a property because of mortgage or maintaining cost. In addition, even though people's mobility has greatly increased, where you live is still where you work. Residents would be willing to move out to find a better place to work and live. At the same time, the possible housing demand increase from new residents who are looking for a job doesn't exist any longer. So the total housing demand decreases.

In the study area, the condition is different from the traditional conclusion. This can also be explained by population. In Oliver and Broadway East neighborhoods, many residents moved out, which can cause the decrease in population basis. While the residents choose to stay are probably the ones who work around, so the decrease of unemployment rate and the loss of housing units at the same time are understandable.

Poverty Rate

The poverty change of the study area varies spatially, but most of the census tracts had an increasing percentage of population under poverty (Figure 22). The data range from a 19.4 % decrease to a 10.8 % increase. 26.4% of the parcels with housing loss are in the poverty decrease area, while 21.6% parcels with no housing loss are in the same areas. In the four census tracts with the highest poverty increase, there are 50.9% of the total housing loss and 39.3 % of the total housing with no change.

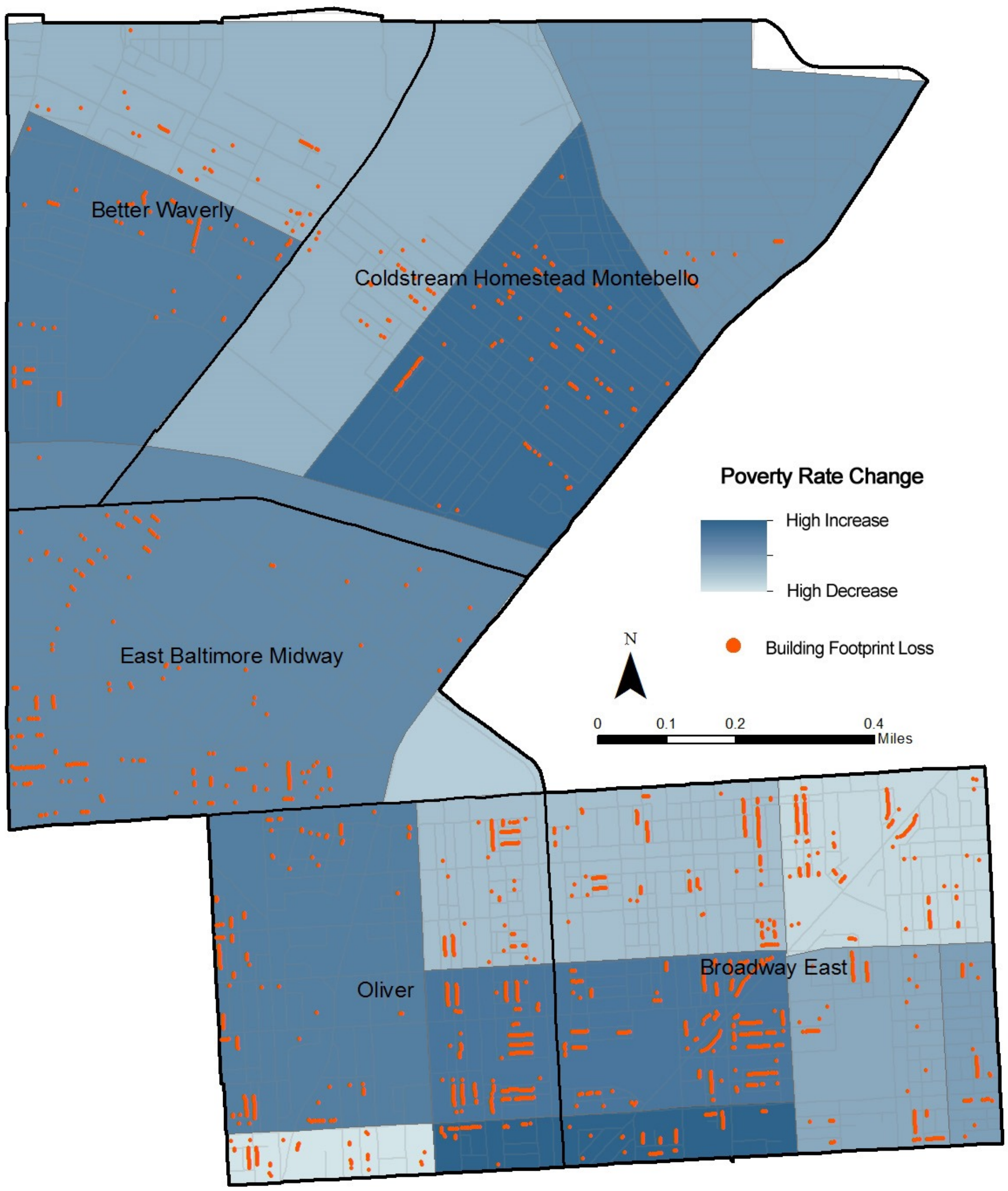


Figure 19. Poverty Condition Changes and Building Footprint Loss

In the spatial perspective, Poverty increase areas are mainly in parts of Oliver, Broadway East, and Coldstream Homestead Montebello, while the poverty decrease areas are in some other parts of Oliver and Broadway East (Figure 23). Unlike the three factors discussed above, the poverty condition changes seem to have no clear relationship with the housing loss. But the existing studies normally agreed that poverty can result in housing loss. Similar to the unemployment rate, poverty rate is associated with the financial condition. It can directly and indirectly results in the financial or physical neglect of the house. The occupants who are lack of income can easily give up the house with the burden of mortgage or because they can't afford the expenses to maintain the house in a good condition. As for the houses for renting, because the rents offered by the tenants are low, the houses are much less profitable. Therefore, the landlords are more likely to abandon the houses.

4.5 Physical Factors

The analysis of the four physical factors used data at parcel level. Different from the census data covering all the study area in section 4.4, the data in this section only cover the residential area, namely the area with building footprint data.

Table 4

Five Physical Factors in the Quantitative Analyses

	Factors	Type	Range	Mean	Std. Deviation	Frequency
Dependent Variable	Housing Loss	Binary variables	1-No longer a standing structure, 0-standing structure remaining			1,849 11,289
Independent Variables	Surrounding Density	Continuous Variable	[0.1, 34.7]	19.31	6.36	-
	Surrounding Vacancy	Continuous Variable	[0, 50]	5.04	7.78	-
	Green Space Accessibility	Continuous Variable	[1, 15]	3.46	2.39	-
	Location in Block	Binary variables	0-Middle of the Row, 1-Two ends of the Row	-	-	2,149 10,989
	Alley House	Binary variables	0-Not Alley House, 1-Alley House	-	-	12,145 993

Table 5

Chi-Square Test for the Housing Loss and Five Physical Factors (n=13138)

Factors	P Value	Chi-Square
Surrounding Density	0.000	4084.98
Surrounding Vacancy	0.000	5121.67
Green Space accessibility	0.001	5131.67
Location in Block	0.000	1123.48
Alley House	0.000	657.92

Density of Surrounding Area

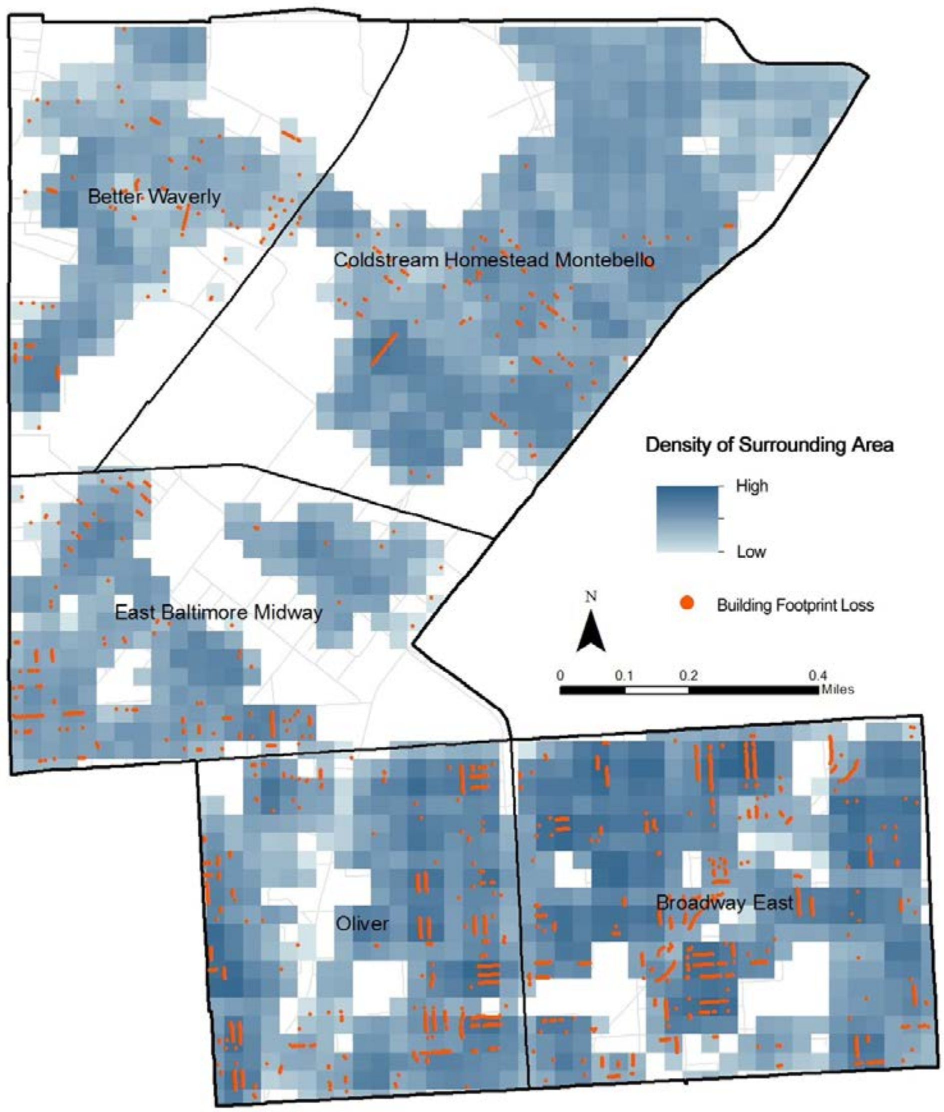


Figure 20. Density of Surrounding Area and Building Footprint Loss

Figure 24 shows how the density of surrounding area changed in the study area. For better illustration, the map was switched from point data to a raster map. The basic cell of the raster map is 150 feet by 150 feet (Bienert et al., 2007).

The average density is about 22 houses per acre (68 parcel units within the buffer area with a 150 foot radius). According to the research by TownCharts (2010), the average housing density in Baltimore is about 5.7 houses per acre, which is only one seventh of the study area. The densest areas in the five neighborhoods are the centers of residential land use areas, while some low-density spaces are near the boundaries between the residential land use areas and other types of land use, like commercial and green space. In accordance with the analysis above, most row houses in Oliver and Broadway East are in the densest area. This is related to the historical construction pattern of row house blocks in these two neighborhoods, which are alley houses behind row houses.

Chi-square test result shows that the density of surrounding area is significantly correlated to the housing loss ($p<0.01$, Table 5). The row houses in the denser neighborhoods are more likely to be demolished. As discussed above, this correlation can be explained by the constructional patterns of different row house blocks.

Housing Changes in Surrounding Area

Figure 25 shows the housing changes within the surrounding area of each house For better illustration, the map is switched into a raster map of 150 feet cell (Bienert et al., 2007).

The spatial variety of housing changes in surrounding area is much more obvious than the housing density. For all the 13,000 residential parcel units in the study area, the number of housing changes within the 150 foot buffer area ranged from 0 to 50 (Table 4). About 39.4 % of them didn't experience any change in the surrounding area. More than half of them (51.9%) have only one or no housing loss in the surrounding environment. The neighborhoods with severe housing loss, however, also exist. The highest housing loss area has even lost 50 houses in the 150 foot radios buffer area. These areas are in Oliver and Broadway East neighborhoods.

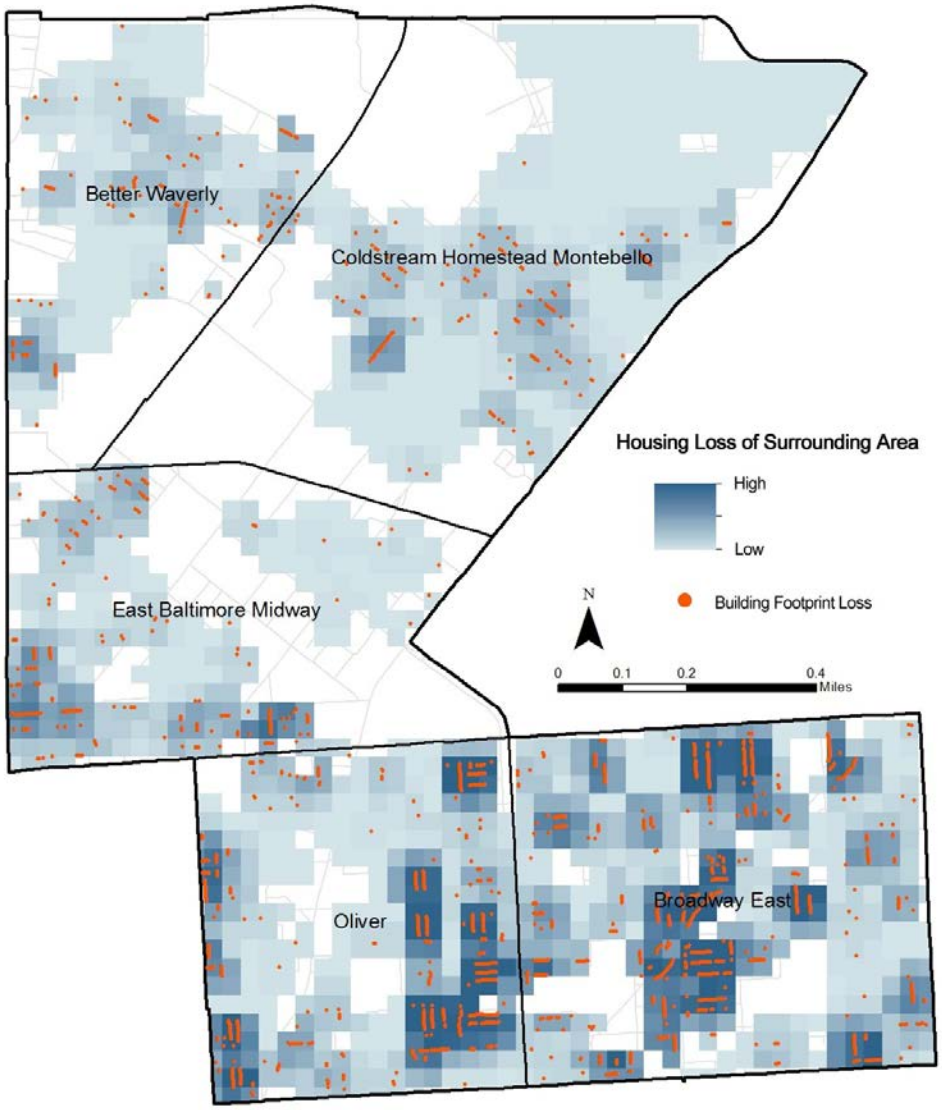


Figure 21. Housing Changes in Surrounding Area and Building Footprint Loss

Chi-square test result shows that the housing change in the surrounding area is significantly correlated to the housing loss ($p<0.01$, Table 5). Therefore, the new housing loss in more likely to happen in the area where there are more vacant lots.

Green Space Accessibility

Figure 26 shows the green space accessibility of the study area. For better illustration, the map is switched into a raster map of 150 feet cell (Bienert et al., 2007).

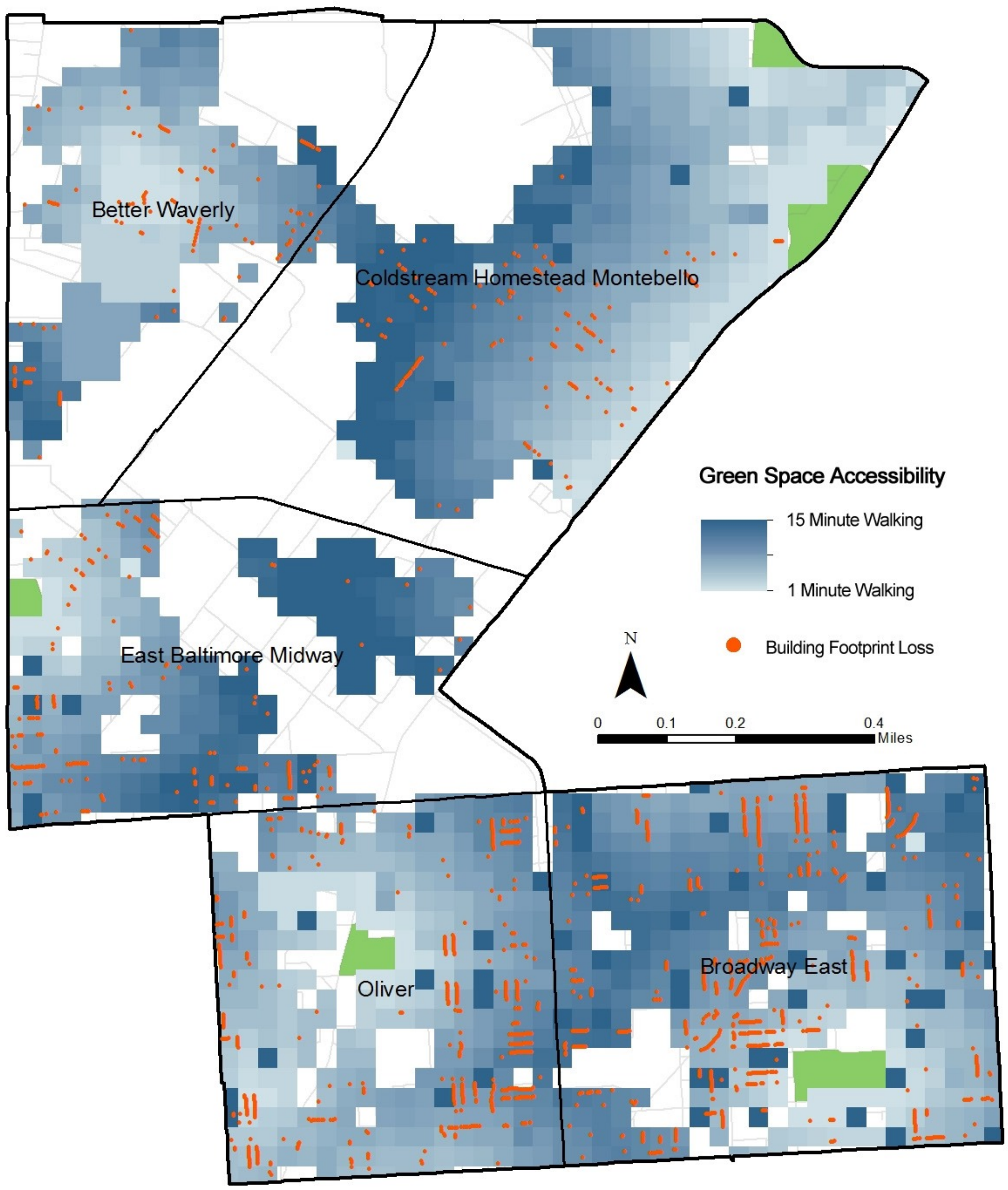


Figure 22. Green Space Accessibility and Building Footprint Loss

All points in the whole study area are in the 15-minute walking distance to the nearest green space (Table 4). This is attributed to two elements. The first is that the neighborhoods were designed with green space in the center, and the second is the high density of alleys.

Chi-square test result shows that the green space accessibility is significantly correlated to the housing loss ($p<0.01$, Table 5). The areas closer to the green space have less housing loss.

Location in Block

Figure 23. Location in Block and Building Footprint Loss in Oliver

Figure 27 shows the location in the neighborhood of each house in the study area. For all the 13,138 parcels in the area, 2149 (16.4%) of them are at the either end of the row (Table 4). Some of the rows are short with only five or six row houses, like the ones in Oliver neighborhoods. Some long rows can have more than 15 houses.

Chi-square test result shows that the location of a house in the row is significantly correlated to the housing loss ($p<0.01$, Table 5). The parcels at the two ends of the row are more likely to have housing loss.

Alley House

There are total 993 Alley houses in the study area, all of which are in Oliver and Broadway East. These Ally houses are narrower, smaller and built behind the regular row houses. Figure 28 shows the alley houses in Oliver neighborhood as an example.

Chi-square test result shows that the location of a parcel in an Alley is significantly correlated to the housing loss variable ($p<0.01$). The parcels at the two ends of the row are more likely to have housing loss.

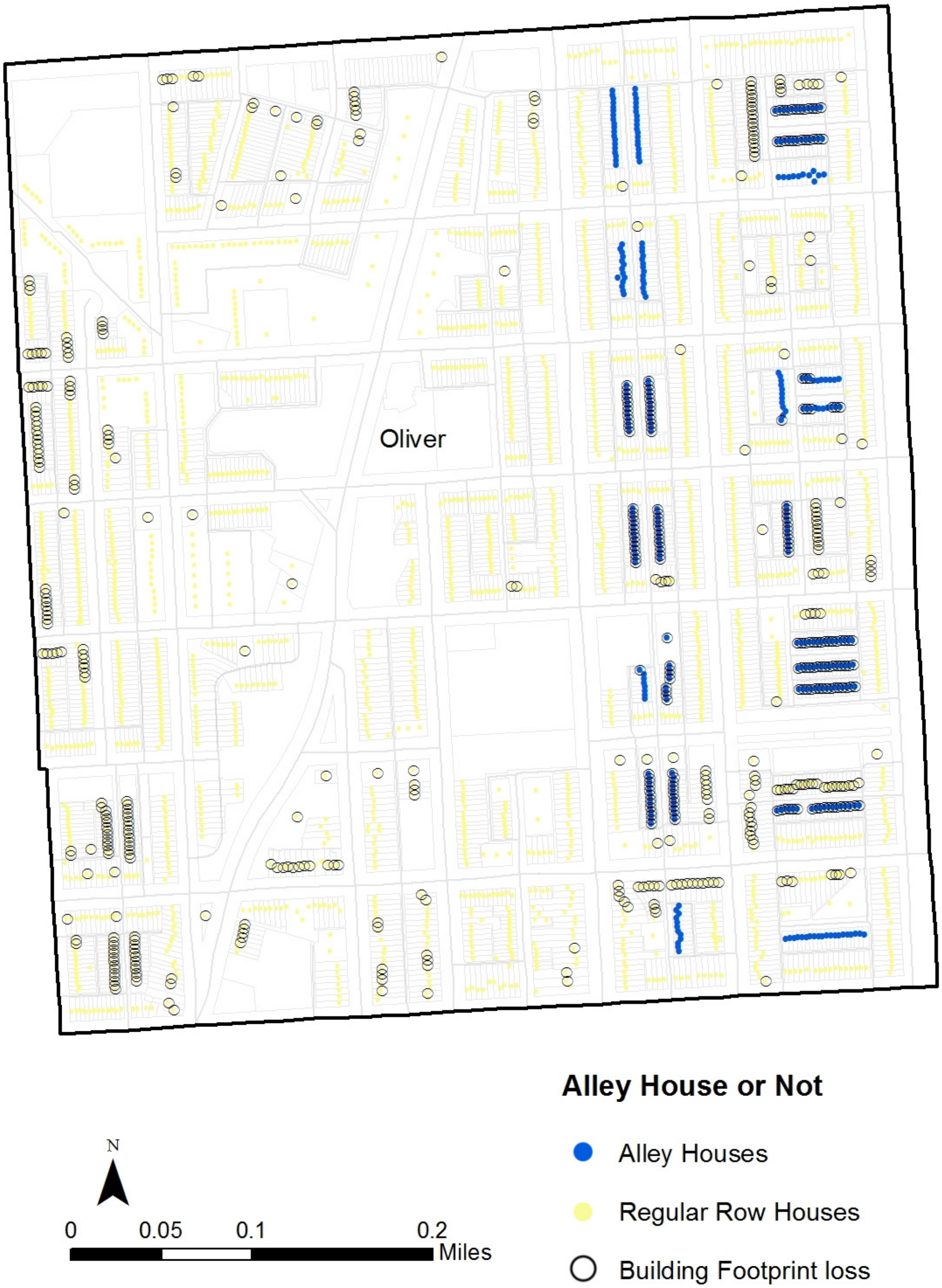


Figure 24. Alley Houses and Building Footprint Loss in Oliver

Chapter 5: Policy Implications

5.1 Vacants to Value

Vacants to Value (V2V) in Baltimore is a program of the City of Baltimore launched in 2010. Its initiative is to solve Baltimore's vacant and abandoned building problem and turn it into an opportunity cleaning up and redeveloping these properties. Although Baltimore's vacant and abandoned building stock is often viewed as a problem, the city believes V2V can help raise property values, create community amenities, increase local tax revenue, and attract new residents and businesses.

Figure 25. House Involved in the Vacants to Value Program
(Taken by Jingyu Tu, 2013)

In V2V, the city has designated a set of Community Development Clusters, where it's "forming partnerships with multiple non-profit and for-profit developers interested in investing in these areas" (City of Baltimore, 2010). For city-owned vacant lots, the Land Resources Division streamlines the disposition to make lots transferred to developers faster and easier. While for privately owned properties, the city pushes owners to rehabilitate or sell/auction them, so that developers can buy and redevelop them. During the redeveloping process, the demolition is a necessary method that can cost many expenses and influence nearby environment.

5.2 Policy Recommendations

First, change the high-density, residential-dominant, mixed-use landscape of the row house neighborhoods. Row house neighborhoods were the heritage of history to Baltimore. They made the rapid development during after-war industrialization in Baltimore possible. Those narrow houses made affordable housing for the working class, and the mixed land use allowed them to walk to everywhere in daily needs without transportation expenses. However, in recent days, the spatial form of Baltimore row house neighborhoods was out of date. One of the principles of row house neighborhoods redevelopment is to decrease the contracture density. This changing direction was also brought by Johnson and Hoolander (2014) in their vacant lots redevelopment project.

Second, to change the physical form of current row house neighborhoods, demolition can be an effective method. However, demolition needs to be carefully planned. As we can see in the research, row house neighborhoods can be so different from each other in both socioeconomic and physical perspectives. Even at the micro level of each row house, they can be different in the same neighborhoods, the same block, or even the same row. So it's clear that a comprehensive place-oriented demolition strategy is needed.

Actually, since the 1950s, Aggressive planning strategies have been applied to demolish row houses in the large amount. Even though the row house has been seen as an outmoded housing type, and it was not the choice of postwar planners to cure the urban housing crisis, the massive demolition still got many critics (Cohen, 2001). Since then, demolition was regulated to be applied to the units the city had identified as unsafe (because of safety hazards or storm or fire damage) and properties about which the city received complaints from neighbors about health and safety hazards.

But demolition is not therapy for all the questions. It has many limitations. First of all, demolition can be a heavy burden for the city. According to Cohen (2001) about $5 million was spent annually on scattered demolitions. The vacant lots after demolition can have other negative influences on the surrounding environment. Even though, advocates claim that the demolition is an effective way to control crime attracted to those unsecured, vacant homes, many argue that vacant lots are also the birth places of different crimes.

According to the thesis analysis, the most effective demolition is to pull down the alley houses. Getting rid of these small, poor-quality and mostly vacant row houses cannot only decrease the construction density, make room for parking space and green space needed by residents, but can also have less negative influence upon the street view. Since they were built behind the regular row houses, the demolition will not form the ugly snaggle-tooth appearance. From the efficiency perspective, the demolition of alley houses by row can also cost less of the city. Also on the basis of expense concern, demolition of the row houses at the ends of the row is a cost-effective choice as well.

Third, V2V focuses on redevelopment, but the decline is "contagious" in the study area. This thesis together with many existing researches showed that housing abandonment and demolition are highly influenced by the adjunct environments and always clustered together. In the high-density row house neighborhoods, this phenomenon is obvious.

So the city needs to spare some energy to some areas where housing loss is more likely to happen. These areas are always in the certain location with unique characteristics discussed in the thesis. If the city only focuses on the redevelopment of Community Development Clusters that have better potentials, it would polarize the condition of different areas in the same row house neighborhoods. To take care of these areas, the city can apply the emergency demolition or temporary reuse as to control the condition from getting worse.

Fourth, V2V aims to redevelop the Community Development Clusters in a fast pace. In practice, the lots being temporarily vacant may still affect the neighborhoods. Thus finding an alternative redevelopment method for temporary use is necessary. Redevelopment into green space is the first choice. The current redevelopments of vacant lots into urban garden, small green space has already been proved to be successful (Langdon, 2001).

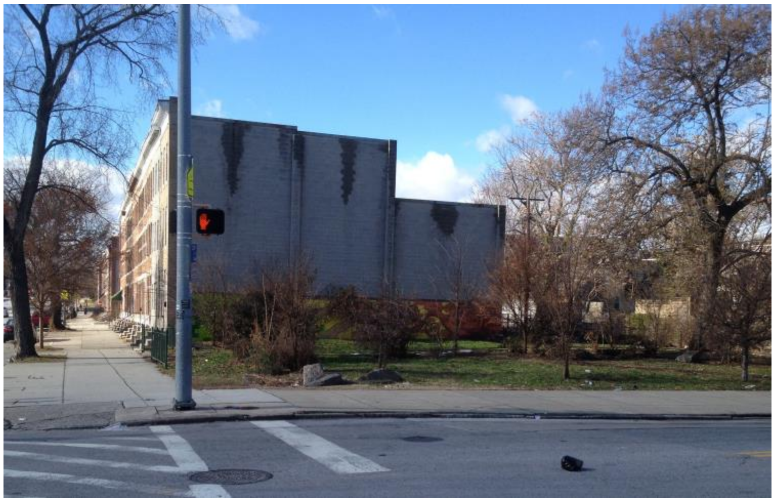


Figure 26. Empty Lots Reused as Green Space
(Taken by Jingyu Tu, 2013)

Chapter 6: Conclusion

6.1 Row House Building Footprint

This thesis had two main objectives. The first was to understand the pattern of construction and demolition of the Baltimore row house via the building footprints. Baltimore's row houses form the unique landscape of high-density, residential-dominant and mixed-use neighborhoods. Those neighborhoods are walkable neighborhoods initially built for the working class in the early 20th century. In the study area, the row house block mainly came with two patterns. The first is the square block with regular row houses outside along the streets and smaller alley houses inside along the alleys. The second is the two housing rows back to back, with bigger parcels and better built houses.

The building footprint change shows that from 1972 to 2010, the whole study area suffered from housing loss. About 14% row houses were demolished. From the spatial perspective, the housing loss was different between the five neighborhoods. This is partially related to the row house block patterns. In the first block pattern, alley houses were often demolished row by row to improve the living conditions of other row houses in the same block. Many of the vacant lots were reused as parking lots or green spaces. While in the second block pattern, the housing loss was randomly scattered, and usually the vacant lots were redeveloped into green spaces.

6.2 Related Factors

The second objective of this thesis was to investigate how the socioeconomic and physical factors are related to the building footprint changes.

Qualitative analyses of the socioeconomic factors showed that in the Baltimore row house neighborhoods, housing loss is more likely to happen in the areas with decreasing population density, decreasing African American population percentage, and decreasing unemployment rate. Meanwhile, the poverty condition was not clearly related to the housing loss.

Quantitative analyses of the physical factors showed that in the Baltimore row house neighborhoods, housing loss was significantly correlated to the five factors, density of surrounding area, housing changes in surrounding area, green space accessibility and location in the block. Housing loss was more likely to happen in the built environment of higher housing density, larger amount of housing loss and worse green space accessibility, and at the two ends of the row.

6.3 Limitation and Further Directions

There are three limitations of this thesis:

1) The mismatching of census boundary and neighborhood boundary in the qualitative analyses of the socioeconomic factors. Even though the 13 census tracts can cover the whole study area of five neighborhoods, their boundaries don't match. So I assume that each census tract is a homogenous unit, and the features of the whole census tract, like the population density, can represent those of any area included in the census tract. For future study, the socioeconomic data of neighborhoods can be used to do quantitative analysis at the neighborhood level.

2) Only two time points were chosen. This thesis chose a time period from 1972 to 2010 because of the row house developing history and data availability. More building footprint data of different time points can be used in further study to do time series analysis.

3) Expand the study area to the whole Baltimore. The study area is only five of the total 278 neighborhoods in Baltimore. There are more neighborhoods with row house to be studied in the future.

Moreover, another researching direction is to compare Baltimore row house neighborhoods with those in other cities. The row house is like a name card to Baltimore, but it doesn't only exist in

Baltimore. Philadelphia is another typical city facing the challenge of row house decline. By studying the two cities side by side, we can find out the differences and similarities between them. We can also check whether the findings in the Baltimore study are applicable in Philadelphia, or other cities.

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