The Transformed Borough:
A Socio-Spatial Exploration of the Bronx

by

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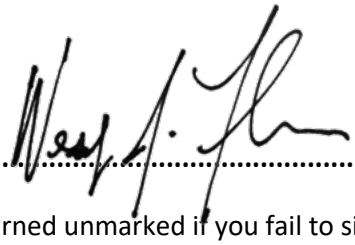
Student Signature: 

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Abstract

This thesis aims to better understand the socio-spatial transformation of the New York City borough of the Bronx and the many changes that occurred in the wake of the Great Depression until today. It focuses specifically on the effects of the discriminatory property lending practices that were documented in the Home Owners' Loan Corporation (HOLC) Residential Security map and have largely contributed to racial and socio-economic segregation within the borough. It also discusses Robert Moses' controversial top-down influence on the city and uses space syntax methods to consider the spatial and environmental effects of the Cross-Bronx Expressway on the borough. The results show that these discriminatory lending practices, combined with White migration to the surrounding suburbs, have contained Black and Hispanic populations within certain parts of the borough and that they have consistently shown lower median incomes throughout the study period. The research also finds a spatial relationship between street configuration and the HOLC map where global choice routes tend to coincide with the boundaries of the various HOLC graded areas. Lastly, the Cross-Bronx Expressway is shown to have spatial effects on the street network, especially at more global scales, and it also carries environmental and public health implications on the surrounding community. The research concludes with a discussion of the results and a brief consideration of some of these topics among related research.

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Chapter 1: Introduction and Background

1.1 The American City as Artefact

One of the most compelling aspects of cities is that they are artefacts of cultural, social, economic, and environmental conditions frozen in physical form. As they age, they accumulate layer upon layer of built matter, much like a fossil transforms over years of exposure to natural forces. The evolutionary transformations are derived from the bottom-up and from the top-down; for example, urban growth occurring at the scale of buildings and streets, or institutions and governments imposing planning ordinances and laws which guide development and, ultimately, urban form.

American cities are a unique case study because they are mostly planned on grids, thus, inherently they are products of top-down forces to a certain extent. On the one hand, it is said that grids form a type of 'egalitarian or democratic space', where the equal opportunity to shared resources 'becomes embedded or reflected within the construction of space itself' (Major 2018, 4) (Figure 1). Certainly the Ancient Greeks, the founders of democracy, would have possessed this mindset about their many orthogonal settlements. On the other hand, this top-down view of American cities perhaps establishes a precedent for largely shaping what happens on the ground in ways that are not anticipated. An example of this is seen in the Residential Security maps created by the Home Owners' Loan Corporation (HOLC) as a way to visualise the lending practices occurring across the United States after the Great Depression (A. E. Hillier 2003; Mitchell and Franco 2018). In an effort to curtail the amount of faulty loans being made, the HOLC acted as a Federal Government lender, and it also worked with local lending companies to create security maps of 239 cities across the country, each colour-coded based on the levels of risk associated with lending to various neighbourhoods (A. E. Hillier 2005). The consequences of these lending practices created racial and socio-economic inequalities (still existent today) on top of other systems of segregation 'even in places not commonly associated with "Jim Crow" segregation laws' from decades earlier (Mitchell and Franco 2018). These lending practices became known as 'redlining' because of the red lines

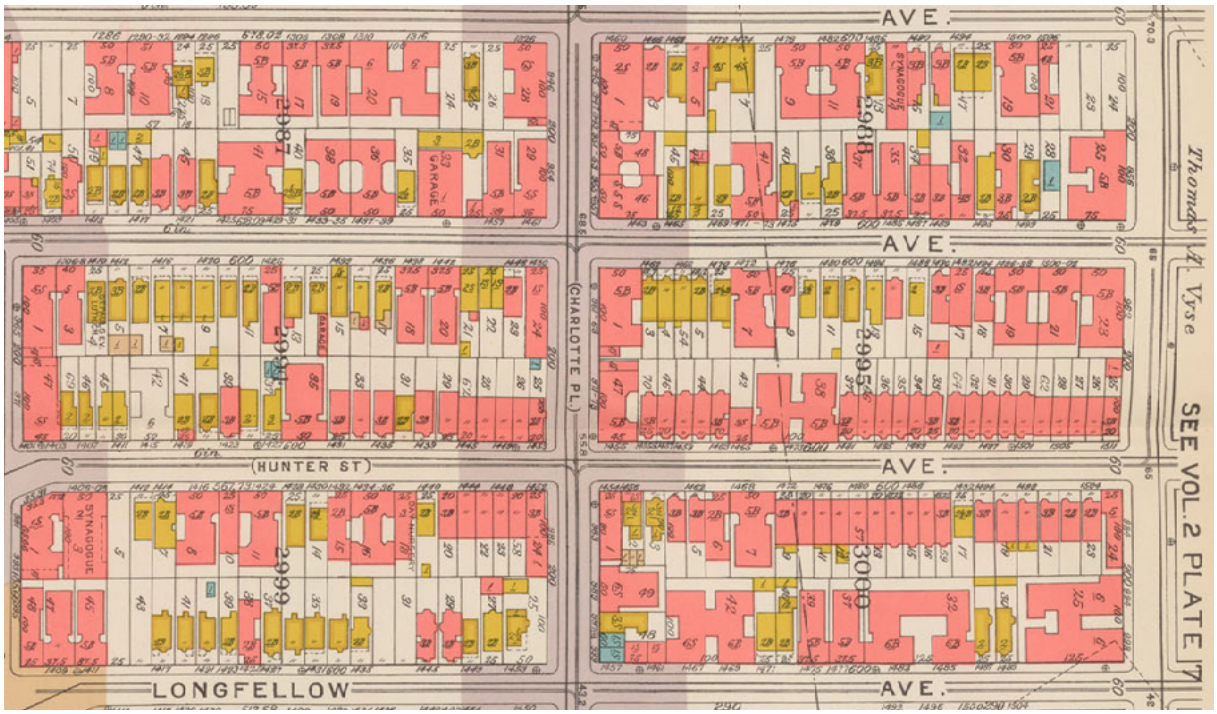


Figure 1 The 'democratic' space created by the grid: excerpt from Plate 38 of The 1942 Atlas of the City of New York Borough of the Bronx
Image source: New York Public Library Digital Collections

that lending agencies would draw around the less desirable neighbourhoods (A. E. Hillier 2003). Understanding access to credit as an 'underpinning of economic inclusion and wealth-building in the U.S.', the very ethos of these discriminatory lending practices seems to contradict the idea of the grid as an equaliser, a catalyst for 'egalitarian or democratic space' (Mitchell and Franco 2018; Major 2018). This contradiction has greatly shaped the American city over time, and these top-down forces have cemented social, economic, and racial conditions into spatial artefacts that are worthy of study.

1.2 New York City and The Bronx

The most populous American city certainly did not avoid these top-down forces occurring nationally, and it even had many of its own local government efforts that shaped it into the urban artefact widely known today. Much of New York City's boroughs are built on grid systems, perhaps the most well-known one is that of Manhattan based on the 1811 Commissioner's

Plan. HOLC security maps were created for all five boroughs of the city, so the practice of discriminatory lending was very much present, and it influenced housing not only within the city, but also into the suburbs where middle class White families moved in large numbers (Jackson 1985; Burns 2003). However, there was another factor shaping New York City from the top-down during much of the 20th Century. Robert Moses, a Parks Department Commissioner who became a national symbol of urban transformation, was responsible for shaping much of the city as it is known today (Caro 1974; Ballon and Jackson 2007). Among the expansive list of projects he was responsible for during his tenure, Moses' fascination with the automobile, combined with his vision of the New York region as a set of islands that were meant to be connected, manifested in a rather large network of roadways cutting through all of the boroughs and into Long Island, Connecticut, and New Jersey (ibid). In looking at the road map in Figure 2, it is not difficult to see that New York City itself seems to stand in the path connecting Long Island to the rest of the surrounding region by car. It was this potential connectivity that Robert Moses worked so tirelessly to realise.

The northernmost borough of New York City, the only one attached by land to the mainland United States, is the Bronx. This borough has undergone a transformative history, from a piece of land first purchased by the Swedish-born Jonas Bronck, to the safe haven for Italians and Jews escaping the Lower East Side tenements for a better life, to the deteriorating remnant of urban renewal efforts in the 1960s and 70s (Gonzalez 2003; Caro 1974). In relation to Robert Moses' efforts to expand the region's transportation network, the Cross-Bronx Expressway is a compelling case study because of the spatial impact it has had on the borough. Built during the 1950s, the Expressway cut through the Bronx and displaced many residents (Caro 1974). Today it remains as a large piece of infrastructure in the network of roadways that circulate through New York City. However, as Jacobson et al. (2005) point out, 'although highways facilitate travel and commerce, they also expose people nearby to ambient risks, including vehicle emissions, noise, and acute obnoxious releases from traffic accidents involving hazardous materials'. The spatial effects of the Expressway, combined with the demographic

Figure 2 1956 Shell Oil Company Map of Metropolitan New York and Long Island (the Bronx highlighted in white)
Image source: David Rumsey Map Collection

and configurational transformation of the Bronx, form compelling topics which will be the main concerns in this research.

Figure 3 1950 construction progress of Cross-Bronx Expressway bisecting the street network
Image source: 'Discovering NYC' Twitter

1.3 Research Focus

The idea that New York City is largely an artefact of top-down planning, combined with an interest in the Cross-Bronx Expressway as an object of severance (a bisection of the street network), prompted the main enquiries for the study (Figure 3). This research will attempt to understand the ways in which lending practices and space itself have shaped persistent socio-economic and racial segregation within the borough by using space syntax analysis

and GIS mapping techniques. It will study the spatial impacts of the Cross-Bronx Expressway on the movement network using both historical and contemporary maps. And finally, it will conclude with a discussion of the findings and a framing of the enquiry within a broader realm of persistent segregation and related research on public health.

1.4 Research Questions

1. To what extent did discriminatory lending practices create the conditions for persistent racial and socio-economic segregation within the Bronx?
2. To what extent, if any, does the contemporary street configuration reinforce or even strengthen the potential for natural movement throughout the Bronx and further isolate the HOLC lending areas from each other?
3. What were the long-term spatial effects of the Cross-Bronx Expressway's construction on the local movement network?

Chapter 2: Literature Review

2.1 Introduction

The literature review will be divided into three parts as follows. Firstly, there will be a discussion of existing knowledge regarding New York City morphology and the impact of Robert Moses during the 20th Century on the city's infrastructure. Then the review will discuss concepts of redlining and environmental racism – processes which took place in American cities, systematically preventing racial minorities from adequate housing and even exposing them to environmental harm or public health risks. And lastly, concepts of spatial segregation and spatial justice will be discussed.

2.2 The Legacy of Robert Moses

New York City was originally a 17th Century Dutch colony – later settled by the British – and it subsequently played a major role in the American Revolution to become the largest, arguably most important economic and cultural capital of the United States (Burns 2003). Settlement began in the lower part of Manhattan Island, and over time, expanded into the five boroughs known today. Morphologically, the famous Commissioner's Plan of 1811 defined an orthogonal grid on Manhattan, which was considered 'a vision of brazen ambition…a living framework, which enabled the city to grow and evolve over time' (Ballon 2012, 13). In the words of Rem Koolhaas, it was 'the most courageous act of prediction in Western civilization: the land it divides, unoccupied; the population it describes, conjectural; the buildings it locates, phantoms; the activities it frames, nonexistent' (1994, 18–19). The other boroughs would loosely adopt their own 'offset grids' (multiple grid patterns intersecting each other) over time, permutations of which became a pattern in many other American cities (Major 2018, 62). It was as if, at the time of the Commissioner's Plan, New York had a sense of just how big and important it would become, setting the stage for a playground of unprecedented development.

Then came the 20th Century, where the emergence of the automobile, the development of

the surrounding suburbs, and the ambitious and powerful public commissioner Robert Moses began transforming the city (Caro 1974). In some ways, the scale of Moses' impact 'fits with New York's distinguished history of daring, large-scale public works', however, never before had the city experienced such a physical transformation by a single individual (Ballon and Jackson 2007, 65). During his thirty-four-year tenure, he was responsible for overseeing a wide range of projects, 'including beaches, swimming pools, playgrounds, parks, and golf courses; bridges, parkways, and expressways; garages and a convention center' (ibid). Robert Caro's famous 1974 book, *The Power Broker: Robert Moses and the Fall of New York*, paints a rather dark picture of Moses (as the title might suggest), calling him on the one hand 'America's greatest builder', yet also arguing that he abused his power and was responsible for the displacement of 250,000 people during his urban renewal efforts – a combination of building expressways and clearing slums for more adequate housing (19). Ballon and Jackson (2007) contextualise Caro, noting that 'since the 1980s, Moses's reputation has been rising, propelled by a fear that New York can no longer execute ambitious projects because of a multi-layered process of citizen and government review' (2007, 65). Whatever the mixed opinions of Moses may be, his ambition rested on the shoulders of other large projects before him that have shaped New York City: the Commissioner's Plan, the Croton water supply system, the Brooklyn Bridge, the parks of Frederick Law Olmsted, and the subway, to name a few (ibid).

One of the aspects in particular that makes for a compelling space syntax study is the notion of Robert Moses' expansion of the expressways throughout New York City. From the point of view of B. Hillier et al. (1993), it could be said that Moses was calibrating the city's (and region's) 'natural movement', a fundamental principle in space syntax theory which states that spatial configuration is the 'primary generator' of movement within a network (31). Thus, the configuration of New York as a series of interconnected islands perhaps necessitated support for movement in the form of an infrastructure network that promoted automobile access to the newly constructed suburbs. Penn et al. (1998) also discuss this notion of natural movement as it relates to automobile movement in urban systems. This study showed a correlation

Figure 4 1960s traffic on Long Island: more cars on the road demanded more roadways
Image source: Hemmings Daily

between vehicular flows and integration within the network, suggesting that there is a 'supply and demand [in] urban road space' where more integrated streets constitute more vehicles, and more vehicles constitute more streets on which to move (ibid, 74). New York City fell into this cycle with the emergence of the automobile: as more cars began appearing on the streets, more bridges, expressways, and parkways were constructed to meet the demand and, in turn, produced the capacity for more cars (Burns 2003). It was this supply and demand cycle that Robert Moses predominantly responded to during his time as a commissioner (Figure 4).

Ironically, 'except for a few driving lessons he took in 1926, Robert Moses never drove a car in his life' (Caro 1974, 12). Furthermore, his view of the city was mostly seen objectively, away from the lived experience of the neighbourhoods: 'his preferred point of view for planning

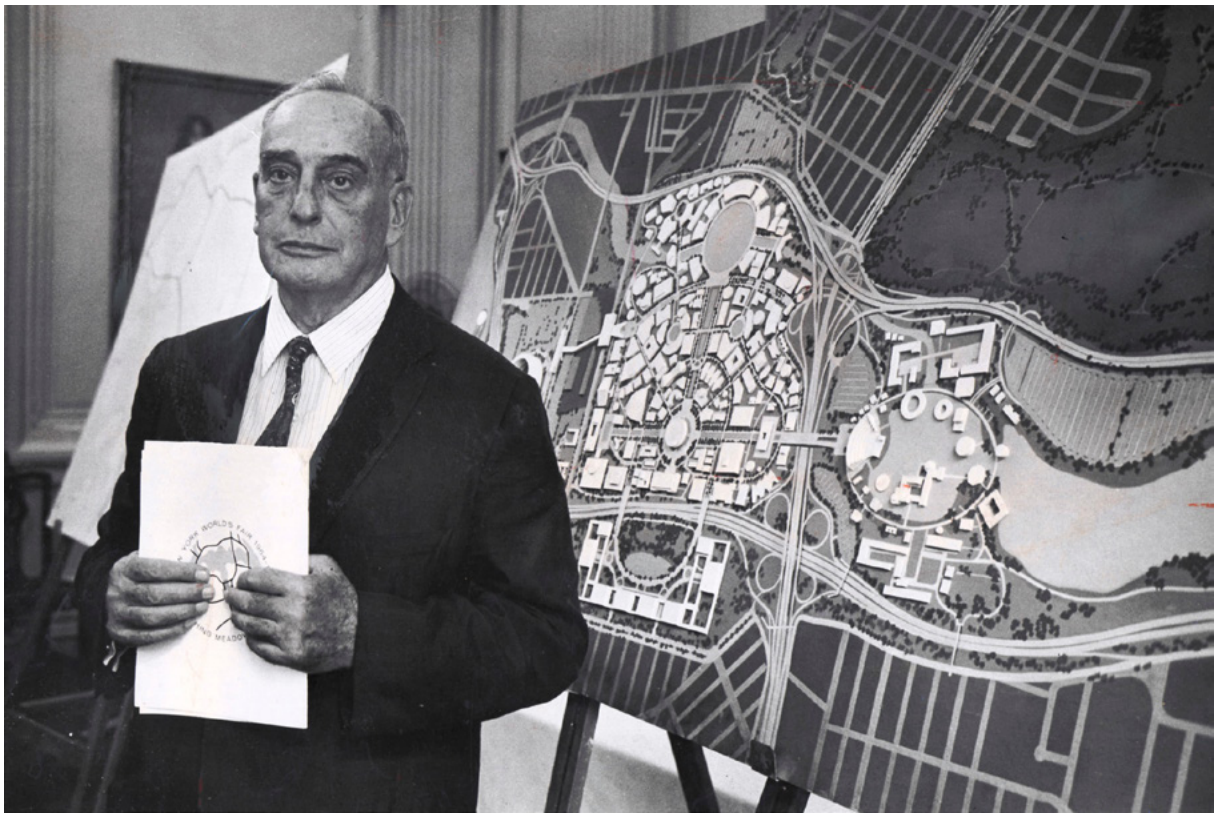


Figure 5 Robert Moses in 1960: he viewed the city from top-down, he saw the city 'as a unit'
Image source: *The New York Times*

was from the sky, where people disappeared from sight and the city appeared as a physical tapestry of land masses, waterways, and structures… Moses saw New York City as a unit' (Ballon and Jackson 2007, 66). In other words, he generally had a view of the city which was highly disconnected from the average citizen (Figure 5). This juxtaposition of seeing the city from above in plan view contrasted with the actual experience on the ground brings to mind the order and structure concept from Julienne Hanson (1989). In her paper 'Order and structure in urban design: The plans for the rebuilding of London after the Great Fire of 1666', Hanson distinguishes order from structure by saying that order is what is seen in plan based on organising principles, whereas structure is what is experienced in the urban realm, providing 'a sense of identity and a grasp of the relation between the parts and the whole' (1989, 22). And this can be seen as an analogy for how Jane Jacobs, the writer and urbanist (and perhaps Robert Moses' biggest rival), saw the city: where Moses saw order, Jacobs saw neighbourhood structure in what she referred to as the 'ballet' of local street life (Jacobs 1961, 96). Although

the turbulent history between Moses and Jacobs tends to be somewhat romanticised—they 'had very few face-to-face encounters'—the two were at conceptual odds with each other, and they do each represent a top-down (order) and bottom-up (structure) city planning outlook, respectively, that moulded New York (Larson 2013, 3).

2.3 Redlining and Environmental Racism

The second aspect of this research, related to the development of New York City's 'natural movement' by Robert Moses, is the notion of displacement from unfair housing practices and environmental injustices on racial minorities.

After World War II, many American cities saw a decline in their populations because of a number of factors including businesses and industries relocating away from inner cities and the rapid growth of the suburbs, prompting many people to relocate (Jackson 1985; 2007, 67). However, this migration was not equal: White middle class families (frequently excluding 'Jews, the Irish, Asians, and others deemed "non-Caucasians"') had the advantage because of better upward mobility, higher paying jobs, and, in a critical new book by Richard Rothstein called *The Color of Law: A Forgotten History of How our Government Segregated America*, a systematic series of racist housing practices which suppressed Black citizens, keeping them from moving out of the inner cities (2017, 235). The principle that Rothstein (2017) points to is called 'redlining', which were actual systems that banks and lending companies used to refuse mortgages to what they considered risky clients in undesirable neighbourhoods—too often, communities of colour. They would also sometimes extract 'unusually severe terms from them with subprime loans' (ibid, vii). Furthermore, this occurred not as a 'vestige' of segregation, but rather a product of 'scores of racially explicit laws, regulations, and government practices combined to create a nationwide system of urban ghettos, surrounded by White suburbs' (ibid, xii). In other words, redlining and accompanying laws were not artefacts of oversight, as was previously assumed even by the Supreme Court in some cases (ibid, xiv). It should be noted

that Hispanic people have also been included within government-organised discrimination, but to a lesser degree than Black communities; this will be addressed further within the context of the Bronx (ibid, 233).

'New York was part of this larger [racially unjust] story', and in many ways was affected most by this change in population simply from its sheer size and diversity of labour (Jackson 2007, 67–68). In fact, the first American suburb—called 'Levittown' after a pair of developer brothers William and Alfred Levitt—was built on Long Island, immediately outside New York City (Jackson 1985, 234) (Figure 6). Middle class White populations moved in large numbers to these kinds of suburbs, leaving other racial minorities in the inner city and exposing them to the urban renewal processes of which Robert Moses was a part. These processes included 'slum clearance', part of a federal programme called Title I which was designed to demolish older housing tenements and relocate people into public housing, often resulting in unwelcoming, unsafe spaces that fell into disrepair and overall property value decline (Collins and Shester 2013). The Bronx was perhaps hit the hardest by urban renewal, redlining, and the phenomenon of 'White flight' (Whites leaving undesirable neighbourhoods for the suburbs). Evelyn Gonzalez (2003) points out that 'the Bronx became a national symbol of urban deterioration' in the 1960s and 70s because of 'waves of arson, crime, and housing abandonment' (2003, 1). Housing was so bad, in fact, that in some cases landlords would actually set fire to their buildings because the insurance reward was higher than the value of the buildings themselves (ibid, 126).

The other aspect of these dramatic changes to inner city life is the existence of environmental racism. This is a term coined by civil rights leader Benjamin Chavis in a 1987 report which pointed to a correspondence between locations of toxic waste sites and communities of colour in the United States ('Toxic Wastes and Race in the United States' 1987). Since then, this concept has been developed and researched further by scholars like Pulido (1996), Cole and Foster (2001), and has even been studied specifically in terms of New York City by Sze (2007) in *Noxious New York: The Racial Politics of Urban Health and Environmental Justice*. This book

Figure 6 1951 Advertisement for Levittown houses
Image source: levittownbeyond.com

examines four low-income neighbourhoods of colour in the city—one is the South Bronx—that were also sites of environmental hazards like sewage treatment plants, waste incinerators, and other noxious facilities which had profound health effects on those communities, including increased childhood asthma rates (Sze 2007). Robert Moses again enters the scene when Sze discusses that his 'race-inflected highway, housing, and open space projects' often happened in the same communities as these noxious facilities (2007, 54). These communities shared an 'active historical memory of the consequences of top-down planning and the worst excesses of urban renewal', so it is as if they were affected again when these noxious facilities were built (ibid). As is often the case with low-income communities of colour that when one burden—like housing discrimination—infiltrates, it can make the community more vulnerable to other kinds of harms that follow.

2.4 Spatial Segregation and Spatial Justice

In looking at forces that have shaped modern cities, it is important to review literature on spatial segregation and spatial justice. Segregation is a complex spatial phenomenon, and it is necessary to establish how the word 'segregation' will be used in this study. In space syntax literature, segregation is mostly concerned with access to the movement network. As B. Hillier et al. (1993) mention, 'the most integrated lines [within a movement network] are those from which all others are shallowest on average, and the most segregated are those from which they are the deepest' (35). Although space syntax analysis will be used in this study, it will use the word segregation not to describe physical movement in space, but rather in the way Rokem and Vaughan point to other meanings such as the 'injustices of state-led spatial planning and housing policies' or 'differing trajectories of housing according to economic status and cultural capital' (2018, 3457). These definitions more closely describe the type of segregation which resulted from housing discrimination in the United States after the Great Depression.

In American cities, segregation is embedded in the DNA of society, although its impact was not fully realised until relatively recently. Massey and Denton (1993) suggest that the word segregation 'disappeared from the American vocabulary' during the 1970s and 80s when other issues like 'homelessness, drugs, and violence in urban America' were pervasive issues on the forefront of society's mind (1). Further, they state that 'segregation is the missing link in prior attempts to understand the plight of the urban poor'; in other words, segregation is an undoubtedly spatial phenomenon which produced the conditions for racial and economic inequality throughout the United States, specifically for Black populations (ibid, 3). Segregation is not always negative, as Peach (1996) points out: there is a type of 'voluntary' segregation, meaning that some ethnic groups choose to assimilate as a way to preserve 'social cohesion', traditions, and speak a common language. Groups like Irish, Polish, and Italians all arrived in the United States and often associated with each other this way, later dispersing to different parts of cities in proceeding generations. However, the other type of segregation is 'imposed', a condition where a racial group assimilates for multiple generations not by choice, as is the case with many Black communities (ibid, 380). In fact, Peach (1996) points to the 'index of dissimilarity' to measure dispersal and intermixture among ethnic groups. In American cities, there is a spectrum where north-western Europeans have been the most intermixed, then southern Europeans and Latinos are more segregated, and finally Black people are the most segregated (ibid, 382).

In terms of the concept of spatial justice, it is impossible for all components of a city to occupy the same space at once, therefore the very nature of cities is that they distribute buildings and other physical artefacts across space, connected by streets in a specific configuration. This often means that there will inherently exist spatial advantages and disadvantages depending on the locations certain people occupy. The notion of spatial justice, as defined by Soja (2009), is 'the fair and equitable distribution in space of socially valued resources and the opportunities to use them' (2). Further, in relating this concept to redlining, Soja states that discrimination imposed on certain populations is 'fundamental in the production of spatial

injustice and the creation of lasting spatial structures of privilege and advantage' (2009, 3). It could be said from this definition that the discriminatory lending that was practiced after the Great Depression contributed to a sense of spatial injustice because it failed to include all people equally in pursuing property ownership, which was noted earlier as the 'underpinning of economic inclusion and wealth-building in the U.S.' (Mitchell and Franco 2018). This system of discrimination, which is fundamentally spatial, has almost entirely excluded Black Americans from participating in the country's real estate economy and has prevented them from building personal wealth throughout most of modern history. The issues of segregation and spatial justice are some of the key themes in this research, and the following section will outline a methodology with which to better understand this principle in the Bronx.

Chapter 3: Methodology

3.1 Overview

In order to investigate the research questions posed, the methodology generally progressed from large to smaller scale. A macro study looked at the morphology and demographics of the Bronx as a whole using census data, Home Owners' Loan Corporation (HOLC) maps, and an analysed street network map. Then an analysis of the local street network surrounding the Cross-Bronx Expressway helped to understand the impact of the Expressway itself.

3.2 Census Data and HOLC Map

The broad strokes of the research began by gathering census data and compiling the information in the mapping software QGIS to investigate the first research question about the persistence of racial and socio-economic segregation in the Bronx influenced by discriminatory lending. In the United States, there are several different scales on which census data are measured, and for this study, census tracts—relatively small areas representing around 4,000 people—were used (Kraiker 2018). Shapefiles (geometry files compatible with QGIS) and corresponding census data were utilised from the National Historical GIS database (NHGIS) online by the University of Minnesota (Manson et al. 2018). Because the Cross-Bronx Expressway was built throughout the 1950s, decennial census data were gathered from 1940-2010, and corresponding race data were joined with the shapefiles to begin to understand demographic changes over this 70-year period (Figure 7). It is necessary to note that the sizes and shapes of the census tracts have changed over time as the population has evolved. Additionally, race classifications have changed over time: in 1940 the two census categories were 'White' and 'Non-White'; then by 1950 onward, three categories emerged which were 'White', 'Black', and 'Other'; and finally in 2000, there were seven categories of 'White', 'Black', 'American/Alaskan Native', 'Asian', 'Hawaiian/Pacific Islander', 'Other', and 'Two or More Races'. 'Hispanic' origin data are reported from the census separately and are available only from 1960 onward. For purposes of consistency in this study, percentage 'Black'

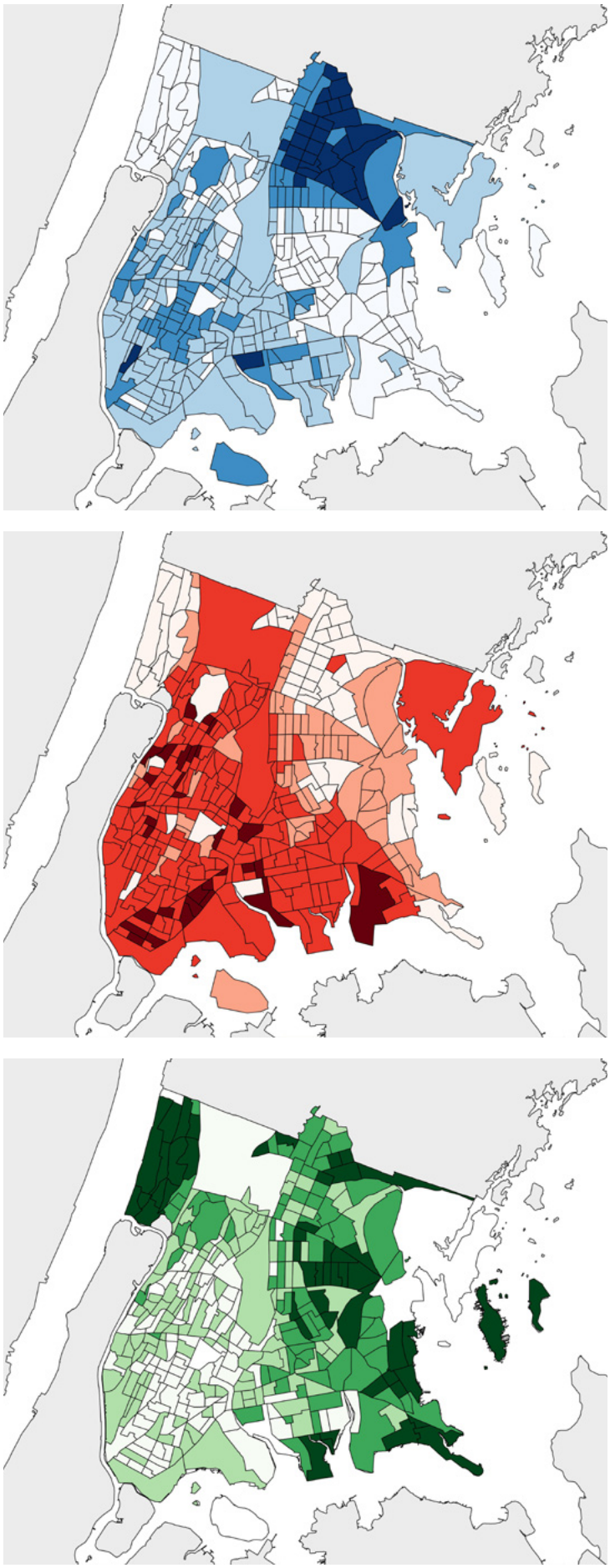


Figure 7 2010 census tract data showing percentage Black population, percentage Hispanic population, and median household income

Image source: Author using NHGIS data

and percentage ‘Hispanic’ populations were calculated per census tract, except for 1940 when the percentage of ‘Non-White’ was used, and no ‘Hispanic’ data were used in 1940 and 1950. It is necessary to point out (as introduced in the literature review) that although Rothstein (2017) notes that Hispanic citizens did not experience the same degree of housing discrimination as Black citizens, Gonzalez (2003) remarks that by 1948, there was a large Puerto Rican population in the Bronx, followed by a growing number with origins in other Latin American countries in later decades (100). By 2000, nearly half of the Bronx population was Hispanic, therefore it is necessary to include this demographic evolution within the research (ibid, 144).

The next step was to gather the redlining data based on Home Owners’ Loan Corporation (HOLC) maps discussed earlier. Each map shows a city (or portion of a city) with coloured areas representing the level of risk—and thus, the potential for redevelopment—that was associated with those communities, and the map of the Bronx is shown in Figure 8. The green represented ‘A (Best)’, the blue ‘B (Still Desirable)’, the yellow ‘C (Declining)’, and the red ‘D (Hazardous)’. These maps have been digitised and made available online by the University of Richmond Digital Scholarship Lab (they are also available as shapefiles), and the map of the Bronx was also incorporated into QGIS for analysis (Nelson et al., n.d.). To use both the census tracts and the HOLC maps, a methodology by Mitchell and Franco (2018) of the National Community Reinvestment Coalition (NCRC) was used as a precedent. In this study, the authors aimed to understand the persistence of economic inequality and residential segregation caused by the HOLC maps by calculating the percentage of the area of the grading (A, B, C, or D) in the original maps and comparing those areas to contemporary conditions. They concluded that nationally over 91% of areas with ‘A (Best)’ classifications are middle/upper income today, and that 74% of areas classified as ‘D (Hazardous)’ are lower/middle income (Mitchell and Franco 2018). Further, the study also found that over 85% of ‘A (Best)’ and 71% of ‘B (Still Desirable)’ areas are currently non-Hispanic White majority and 63% of ‘D (Hazardous)’ areas are currently majority-minority (ibid, 9). This is indicative of a spatial pattern—which has strong economic and racial ties as discussed in the literature review—with a ‘startling persistence of

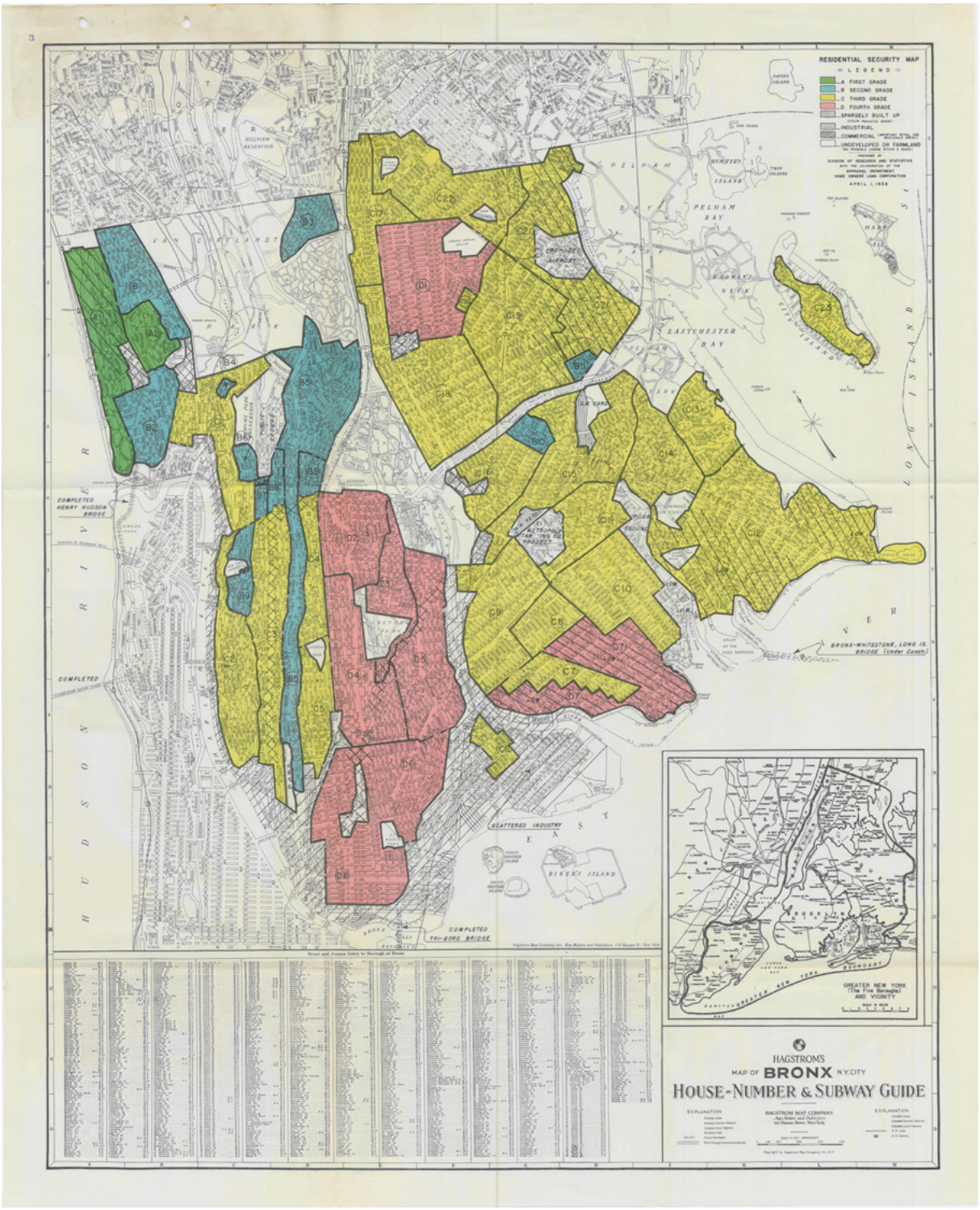


Figure 8 1938 Home Owners' Loan Corporation (HOLC) Map of the Bronx
Image source: University of Richmond Digital Scholarship Lab 'Mapping Inequality' Project

an unequal and segregated urban structure' throughout the country (ibid, 9).

This study used a similar method to the NCRC study, but it was localised for the Bronx using the census tracts and the HOLC map. The study then used the spatial join feature in QGIS—a tool that transfers information between data layers—to assign the A,B,C, and D ratings from the HOLC shapefile to the 1940-2010 census tracts (excluding the decades noted earlier due to lack of data). Percentage Black and percentage Hispanic populations, as well as median household income, were categorised by HOLC category and averaged to determine quantitatively whether the lending practices documented in the HOLC map helped to cause persistent, racially and socio-economically segregated pockets of the Bronx.

3.3 Segment Analysis

Simultaneous to the collection of these census data was the task of drawing contemporary and historical segment maps for analysis. An Open Street Map was used as an underlay for the contemporary map and axial lines were drawn in AutoCAD using the definition by B. Hillier (1996b) as the 'longest and fewest lines needed to cover' a street system (98). The same method was used to draw a historical map. The underlay for this map was the most recent map that could be obtained before the building of the Cross-Bronx Expressway (and other major roads that cut through the borough): the 1922 Ohman's Standard Map of the Bronx downloaded from the New York Public Library Digital Collections online and shown in Figure 9. Both the contemporary and historical street networks for the study included the entire borough of the Bronx and extended south to include upper Manhattan north of 110th street and a small portion of Fort Lee, New Jersey across the Hudson River to the west (Figure 10). Both of these maps were imported separately into Depthmap X software, converted from axial to segment lines after Turner (2007), and analysed for integration and choice at radii 400, 800, 1000, 1200, 1500, 2000, 3000, 5000, and global (n). The two networks were also normalised using the formula from B. Hillier et al. (2012). Even though the contemporary and historical maps were

Figure 9 1922 Ohman's Standard Map of the Bronx
Image source: New York Public Library Digital Collections

very close to the same sizes, this process allows multiple analysed networks to be compared regardless of size. The typical nomenclature of 'NACH' and 'NAIN', for normalised choice and integration, respectively, was used during the study. In the following sections, the measure will be stated first, followed by the radius, for example 'NACH R5000' is normalised choice at radius 5000m. 'RN' will indicate the global radius.

After the historical and contemporary maps were drawn and analysed, they were imported into QGIS and compared against the census tracts and HOLC areas. As mentioned previously

Figure 10 Historical (A) and Contemporary (B) segment maps of the Bronx study area

Image source: Author using Open Street Map and 1922 Ohman's Standard Map of the Bronx

in the work of Amy Hillier (2003; 2005), the HOLC maps were created by the federal government and modelled after local lending institutions throughout the country. The lenders used data like demographics and income to assign grades to various neighbourhoods, but the actual borders were *not* defined by 'any existing set of boundaries, such as census tracts or wards' (A. E. Hillier 2005). This prompted an enquiry about what the logic was in defining the boundaries on the map of the Bronx and whether changes have occurred to these boundaries over time. In comparing the analysed street network with the HOLC areas, it was observed in Figure 11 that the streets with high global choice values (main streets) seemed to coincide with the boundaries between the HOLC areas. In space syntax theory, as mentioned previously, natural movement generates a city's configuration, and 'most movement is through movement, that is, the by-product of how the grid offers routes from everywhere to everywhere else' (B. Hillier 1996b, 127). When cities are considered in this way, choice is the measure of how

Figure 11 Historical street network shown at NACH RN with HOLC grading areas
Image source: Author

likely a particular route will be chosen to move from everywhere to everywhere else, and integration is how deep or shallow a segment is within a system. This prompted the second research question of whether the street configuration has evolved over time to reinforce or even strengthen the potential for natural movement in the borough and further isolate the HOLC areas from each other. If main streets had seemingly informed the boundaries between the HOLC areas, and these areas have been shown to correspond with certain socio-economic and racial demographics, then it is sensible to question the changes to the street network over time in potentially reproducing the spatial conditions which isolate these various demographics within areas of the borough.

To perform this study, ten streets (comprised of multiple segments each) were chosen between sample HOLC boundary conditions throughout the Bronx (Figure 12a). The boundaries were chosen to represent a variety of HOLC area combinations adjacent to each other, for example, between an A and B, a B and C, and a C and D; and all boundaries around the D area in the northeast were analysed because it appeared like an island separated from the C area that surrounds it (numbers 7-10 in Figure 12a). Each segment within the boundary was assigned a number, for example, boundary 1 had 9 segments so they were numbered 101-109 (Figure 12b). Then the choice and integration values of the segments making up the ten boundaries were averaged for both the contemporary and historical conditions at radii 800, 1000, 1200, 1500, 2000, 3000, 5000, and global (n). In locations where segments differed between the contemporary and historical conditions, numbering was kept consistent (for example a segment in the historical map that is split into two segments today—refer to Figure 12b). This numbering allowed the values from the contemporary and historical networks to be exported and compared in the analysis. Further investigation of these boundary conditions prompted a simple standard deviation analysis. This calculation took each of the ten boundary conditions in Figure 12 and calculated the standard deviation of the segments comprising them for the radii mentioned in both the contemporary and historical conditions. This helped to reveal whether a consistency is seen or not among the segment values at different radii.

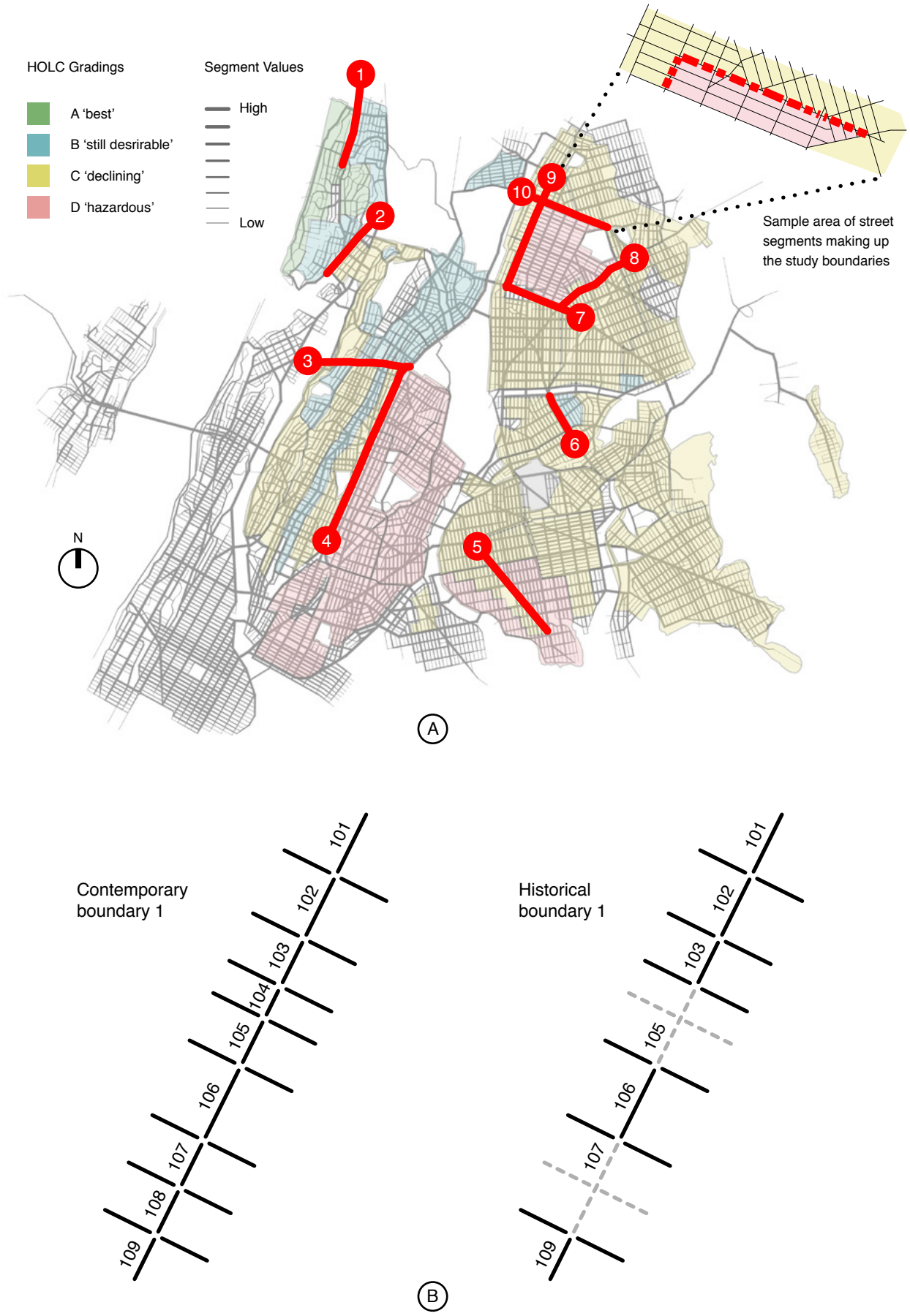


Figure 12 Historical segment map at NACH RN with HOLC areas and ten boundaries for analysis (A) and example segment numbering of contemporary and historical condition (B)
Image source: Author

This study prompted further curiosity about the nature of these boundaries around the various HOLC areas compared with other aspects of the network. In observing Figure 11 more closely, it was noted that there was a linear area running north/south around Grand Concourse valued as ‘B (Still Desirable)’ on the HOLC map and surrounded by ‘C (Declining)’ areas on both sides (labelled in Figure 11). It was noted that this street and other main streets bounding the HOLC areas seemed to have higher values than the segments perpendicular to them. This brought to mind the principle of ‘marginal separation by linear integration’ introduced by B. Hillier (1996a) and discussed further by B. Hillier and Vaughan (2007) and Vaughan (2018). This is a phenomenon where varying land uses or grades of housing ‘may often be in close proximity but separated effectively by being on different alignments, often as part of the same urban block’ (B. Hillier 1996a). Further, the principle suggests that the line is the ‘fundamental land use element’ and that changes occur relatively gradually along the length of the line, but often more abruptly with ‘ninety-degree turns onto different alignments’ (ibid). To understand this further in the context of the Bronx, two small areas were chosen at random locations where multiple HOLC areas met. Figure 13 shows the locations of these areas, one west of Fordham University where B, C, and D areas converge, and the other east of Woodlawn Cemetery between two areas graded C and D. The NACH R5000 values were compared in each area for both the historical and contemporary conditions to test whether the relationship between the main streets and those perpendicular to them have changed significantly over time. Normalised choice was studied because, as mentioned earlier, it is indicative of movement from everywhere to everywhere else within the system. The 5000m radius was chosen because it is large enough to represent larger, natural boundaries within the network (for example, main streets for cars and buses).

3.4 Cross-Bronx Expressway Study

After the analysis of the Bronx as a whole, a smaller study then looked at the Cross-Bronx Expressway to investigate the third research question about its long-term spatial effects on the

Figure 13 Areas selected to study 'marginal separation' compared with HOLC areas
Image source: Author

local movement network. This area was chosen because of a general interest in the Expressway as an object of severance on the street network and also because of the focus of this segment in *The Power Broker's* 37th chapter called 'One Mile' (Caro 1974). In this chapter, Caro tells the story of community members of the East Tremont neighbourhood who fought legal battles with Robert Moses to try and have the Expressway moved to the northern edge of Crotona Park, thus avoiding some 1,530 apartments which would be demolished (ibid) (Figure 14). Looking back, it is clear that Moses won this battle and had the Expressway built as he originally envisioned; however, there were also changes to the street network at the expense of the

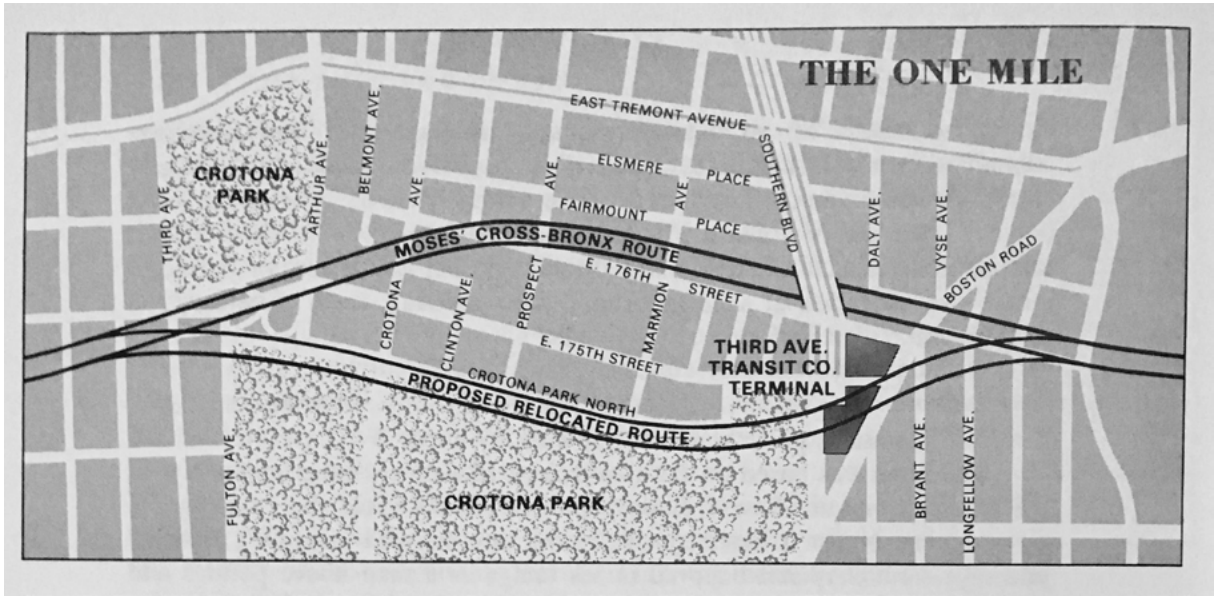


Figure 14 The Expressway's built route versus the relocated route proposed by the community
Image source: *The Power Broker: Robert Moses and the Fall of New York* by Robert Caro 1974

Figure 15 The Cross-Bronx Expressway from above showing trench condition, some streets are severed, others are continuous and bridge over
Image source: Wall Street Journal

Expressway. As the Expressway cuts through the borough, it sometimes is a bridge above the surface streets, and other times it is a trench below. In this study area, it is mostly manifested as a trench with some street segments cut at its intersection and others bridging over it, seen in Figure 15. An analysis was performed by comparing the values of the street segments before and after the construction of the Expressway within the study area to see if there was an impact on the severed streets and the network as a whole. The study area was defined by focusing on a 1800m radius (a local and walkable scale) surrounding the Expressway, centred where it crosses Webster Avenue (Figure 16). A spatial join function was again performed in QGIS which assigns a common value to each segment from the historical and contemporary maps to enable direct comparison between the two. These segment values were exported to Excel and then the percentage change was calculated for all of the lines within the study area for normalised choice and integration at radii 800, 1200, 2000, and 3000, representing a range of walkable distances and neighbourhood catchment area. The percentage change values were then imported back into QGIS so they could be visualised. Additionally, locations of New York City Housing Authority (NYCHA) buildings were downloaded from NYC Open Data and compared with affected street segments within the study area.

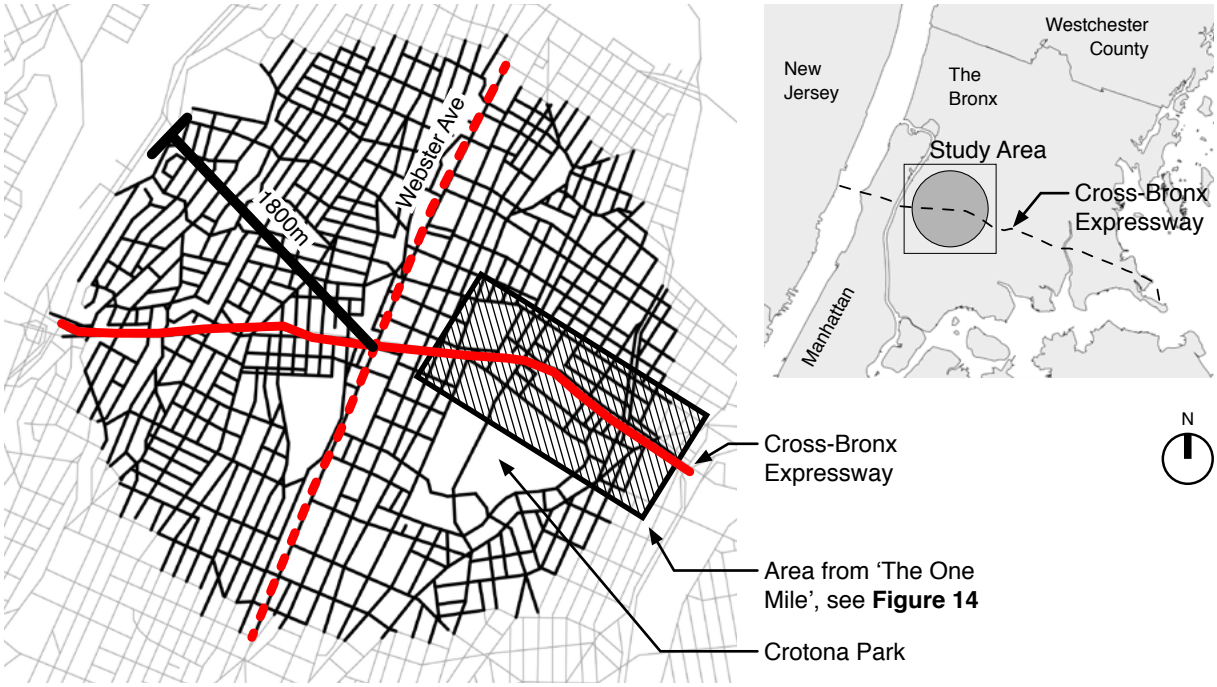


Figure 16 Street segments chosen (in thick lines) for impact of Cross-Bronx Expressway study
Image source: Author

Chapter 4: Analysis

4.1 HOLC and Demographics Analysis

This analysis chapter will be shown in the same order that the research questions and the methodology were presented, and each section will begin by re-stating the question and a hypothesis for each. The analysis of the census tracts and HOLC areas will show the three categories outlined in the methodology: percentage Black, percentage Hispanic, and median household income.

RESEARCH QUESTION ONE: To what extent did discriminatory lending practices create the conditions for persistent racial and socio-economic segregation within the Bronx?

HYPOTHESIS: The lending practices outlined in the HOLC map created persistent racial and socio-economic segregation to a fairly large extent

PERCENTAGE BLACK POPULATION

In Figure 17, each decade from 1940-2010 is presented with percentage Black census tracts and the HOLC graded areas as a reference (Figure 19 shows these same data in a graph and compares them to the percentage Hispanic analysis, discussed further). It can be seen that the demographics change drastically over time, with groupings of tracts with 72-100% Black population forming in the south Bronx between 1950 and 1990, and these mostly correspond to 'D (Hazardous)' HOLC areas. Then from 1980-2000, there is a striking concentration of 75-100% Black census tracts in the northeast part of the borough, changing to 67-89% in 2010. Visually comparing these census tracts with high percentage Black populations, it can be seen that they coincide with the 'D (Hazardous)' HOLC areas to a large extent. And this is verified in the graph in Figure 19 where 'D (Hazardous)' areas start showing averages between 38-45% from 1970-2010, whereas A, B, and C graded areas range from 3-9%, 5-25%, and 12-32%, respectively for that same time period.

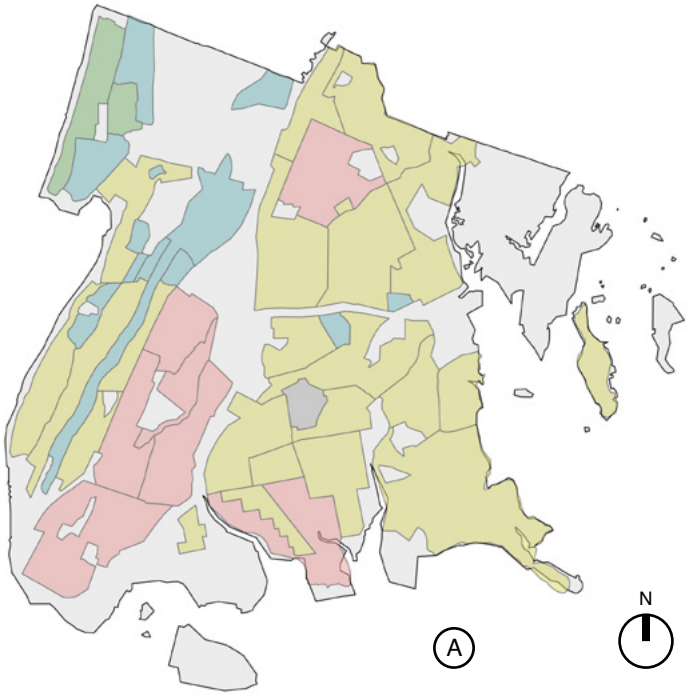
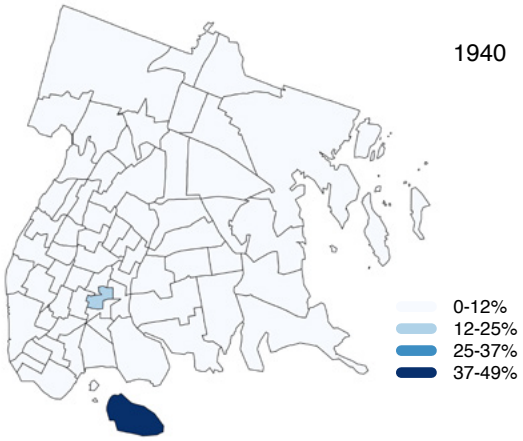
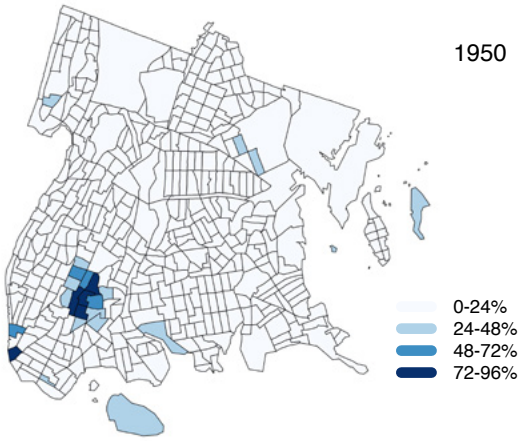
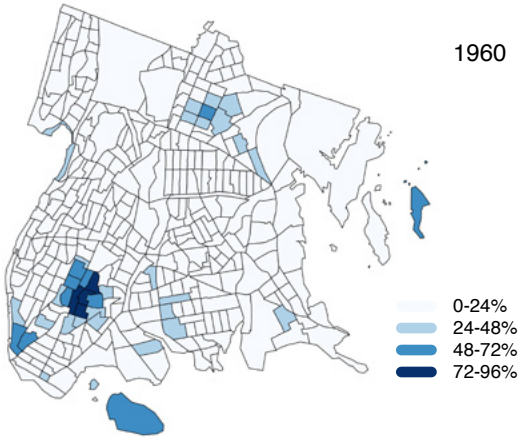
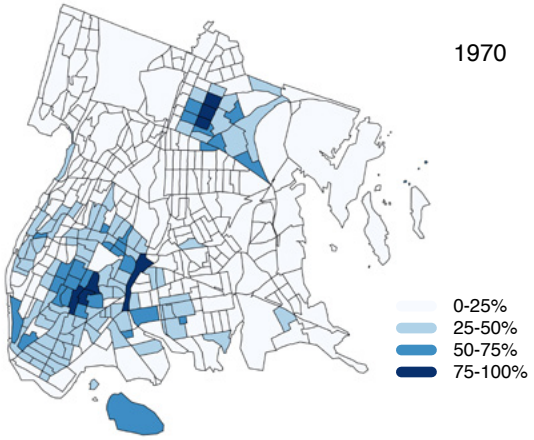


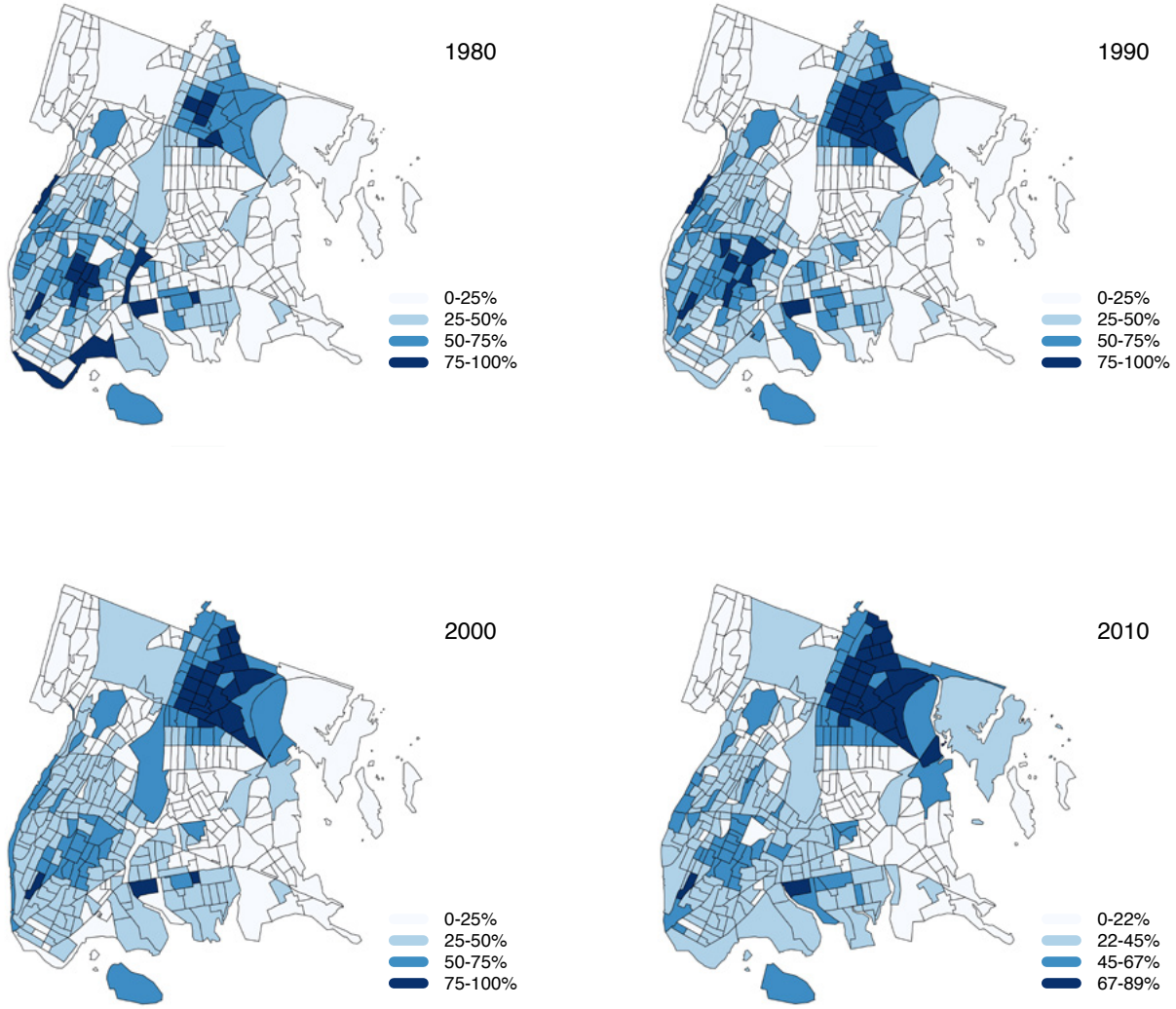
Figure 17 Analysis showing Bronx HOLC areas (A) and percentage Black census tracts from 1940-2010 (continued on following page)
Image source: Author











PERCENTAGE HISPANIC POPULATION

Figure 18 shows the same analysis but with percentage Hispanic census tracts from 1960-2010. Here it can be seen that a similar concentration to the percentage Black exists, though to a slightly lesser degree. Beginning in 1960, there are small groupings in the south Bronx with 50-66% percent Hispanic tracts, and then from 1970-1990 there are groupings from 58-100% seen throughout the borough. And in 2000-2010, a large portion of the Bronx has census tracts between 46-75% Hispanic. Unlike the percentage Black census tract analysis, there is not such a distinct grouping over time of high percentage Hispanic tracts, and there are more majority Hispanic tracts that correspond to B, C, and D HOLC graded areas, rather than mostly D gradings as seen with the previous analysis. This pattern is verified in the graph in Figure 19

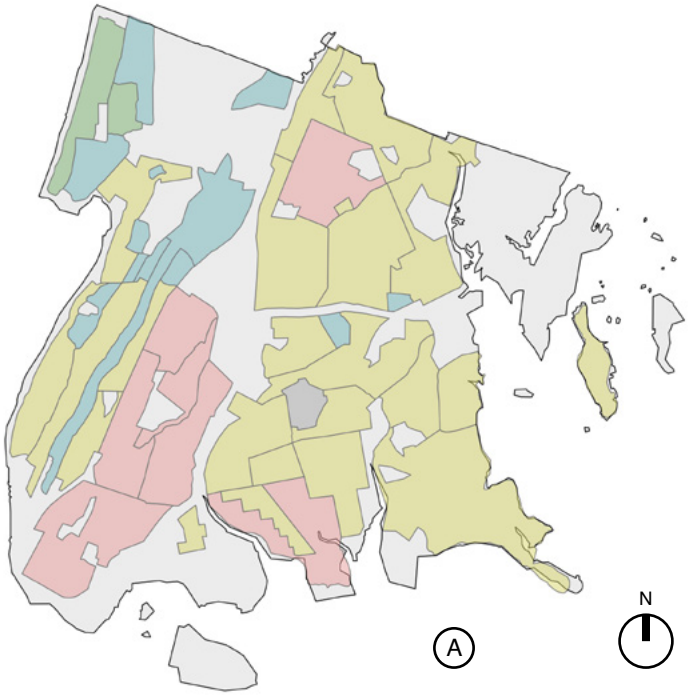
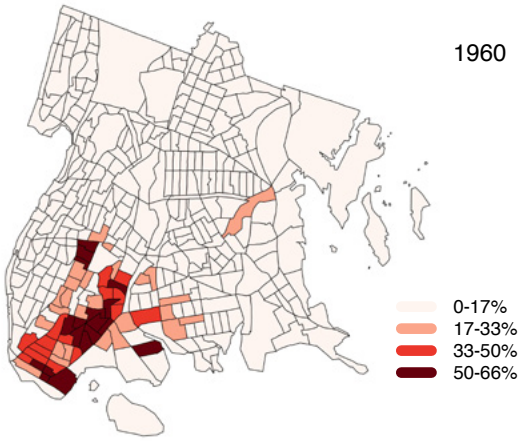
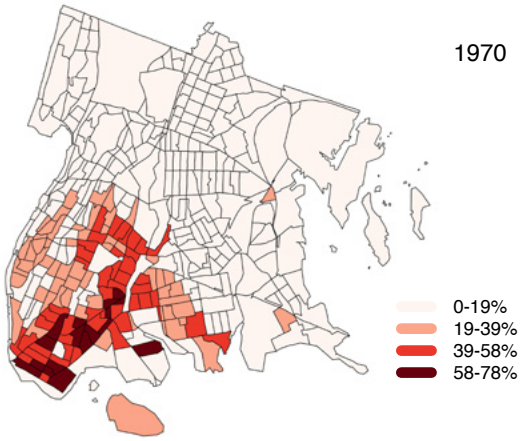
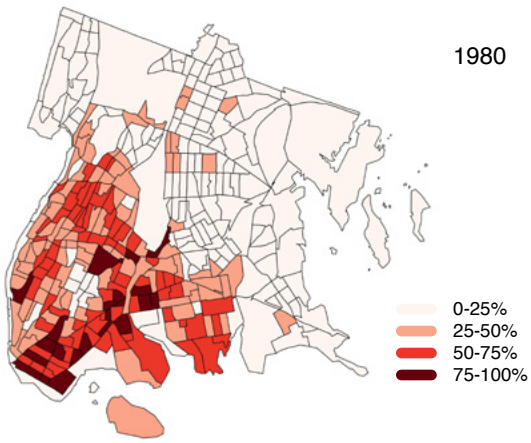
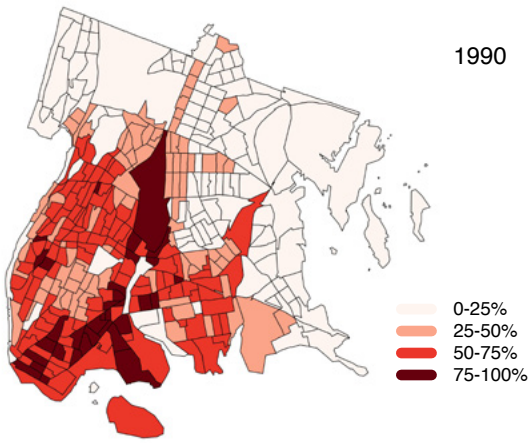


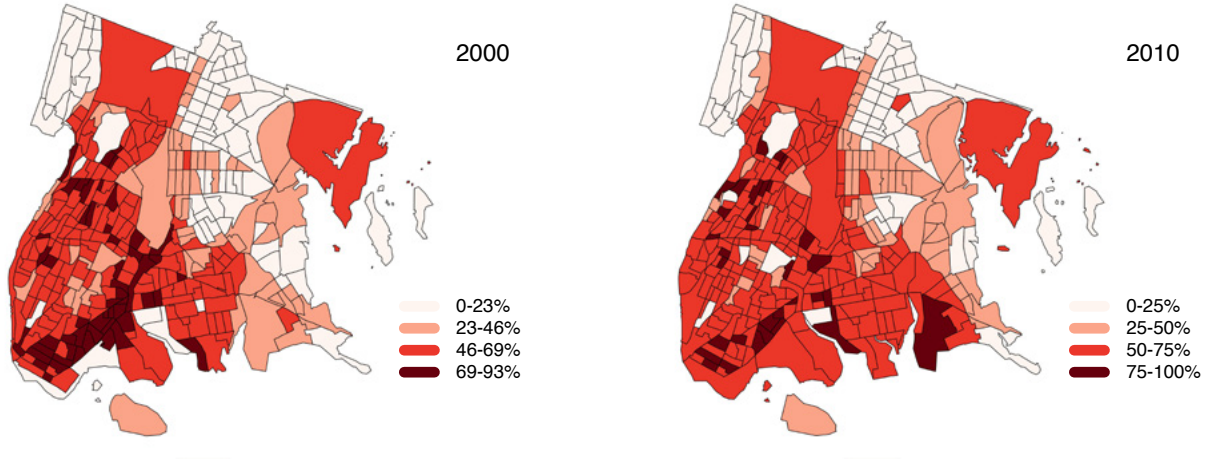
Figure 18 Analysis showing Bronx HOLC areas (A) and percentage Hispanic census tracts from 1960-2010 (continued on following page)
Image source: Author





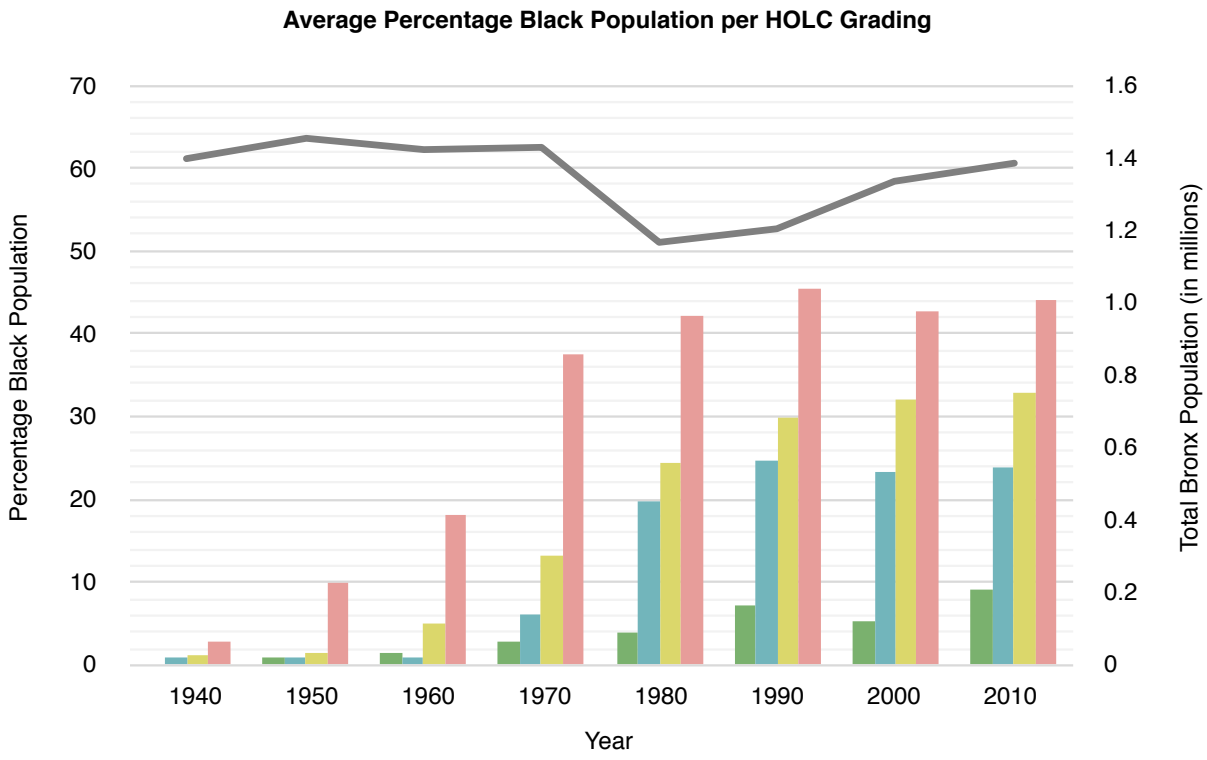






where D graded areas increase from 21-58% average percentage Hispanic from 1960-2010, and B and C graded areas follow fairly closely between 1980-2010 at 28-50% and 26-46%, respectively.

In Figure 19, as previously stated, the percentage Black and percentage Hispanic analyses are graphed together showing the average percentage of both demographics categorised by HOLC grading and compared to the total population of the Bronx for the study period. It can be observed that the percentages of both Black and Hispanic populations increased even as the total population fluctuated within a range of only about 280,000 people, from a low of approximately 1.17 million in 1980 and a high of 1.45 million in 1970. The largest fluctuation in total population over the whole study period only occurred within a 10-year period from 1970-1980. The other aspect to note is that the average Hispanic population is consistently higher than the average Black population within the 'D (Hazardous)' HOLC grading from 1960-2010 (Hispanic population within the 50-60% range versus Black population within the 40-50% range at their highest). Further, it is seen that the Hispanic population is more distributed than the Black population throughout the B and C graded areas, as was noted in the decennial census tract diagrams. For example, by 2010, the average Hispanic population in the B graded area for was only 8% lower than the D graded area versus 20% lower for the Black population.



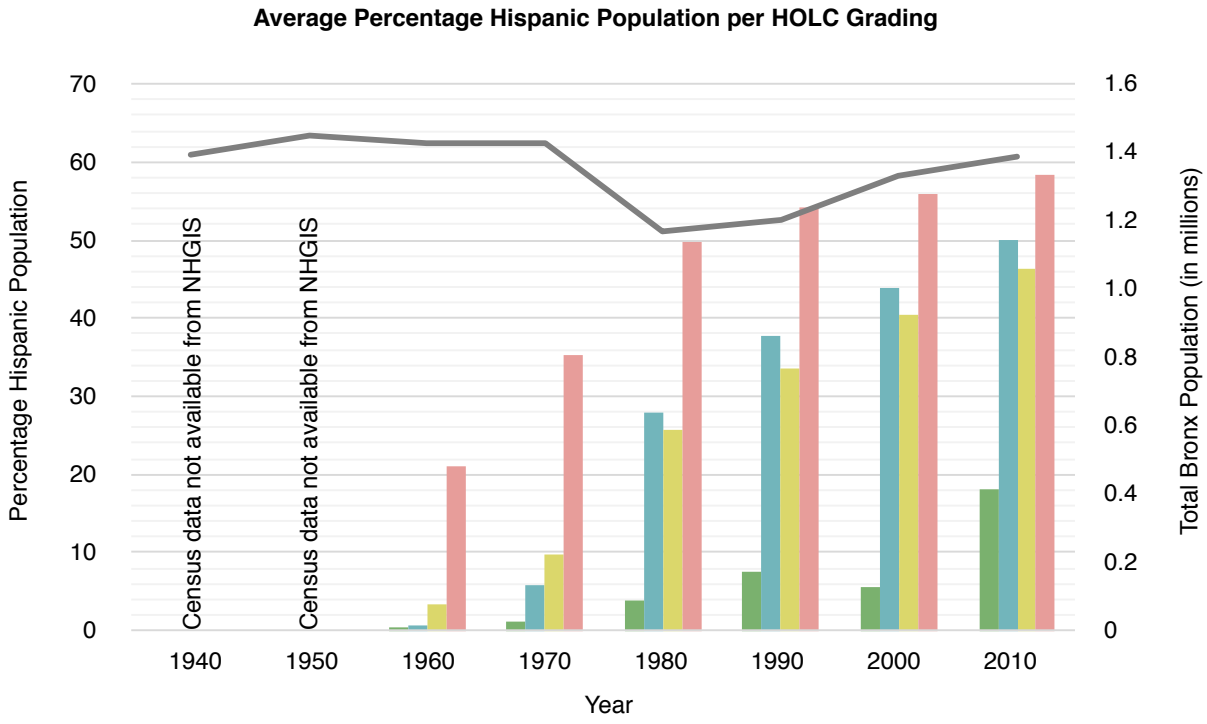


Figure 19 Average percentage Black populations and average percentage Hispanic populations per HOLC grading area, and total Bronx population per decade

Image source: Author

MEDIAN HOUSEHOLD INCOME

Figure 20 shows an analysis of median household income per census tract from 1950-2010 (excluding 1960-1970 due to lack of data) and compares this against the HOLC map. Figure 21 graphs these values in a similar way to the previous Black and Hispanic population analyses. What is seen here is a correspondence between high income census tracts and 'A (Best)' HOLC graded areas, and conversely, B, C, and D tracts showing lower income. The most extreme example is in 2000 where there is an approximately $37,000 USD/year difference between average median income in census tracts with A versus D HOLC gradings. Additionally, the region in the northwest part of the Bronx (neighbourhoods of Riverdale and Spuyten Duyvil, labelled in the figure) which shows the highest median income between $60,607-$100,776 USD/year in 2010 is also the area with the lowest percentage Black and Hispanic populations at 0-22% and 0-25%, respectively for the same period. However, there are also several census tracts in the eastern parts of the borough with median incomes in the high range (mentioned above) which correspond with C HOLC graded areas and higher Hispanic populations from the previous analysis.

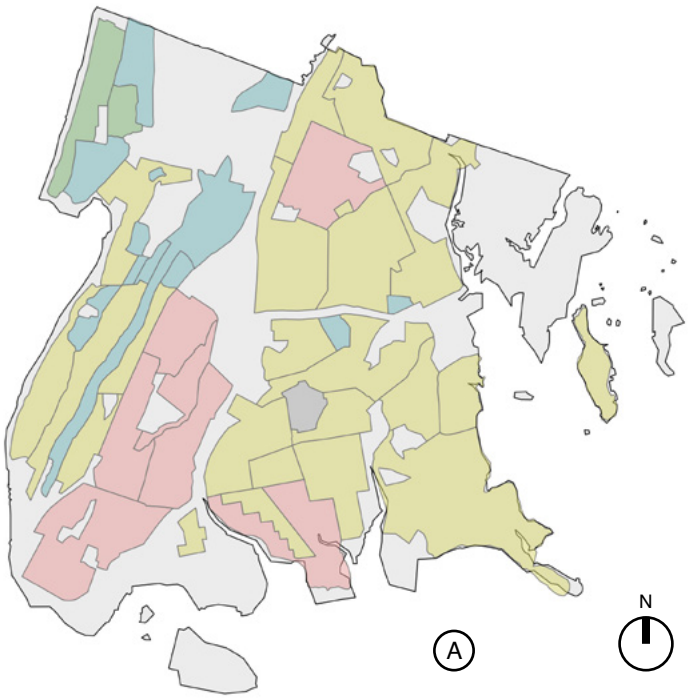
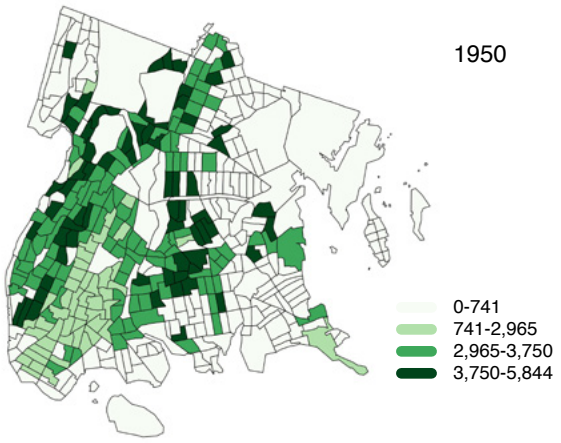
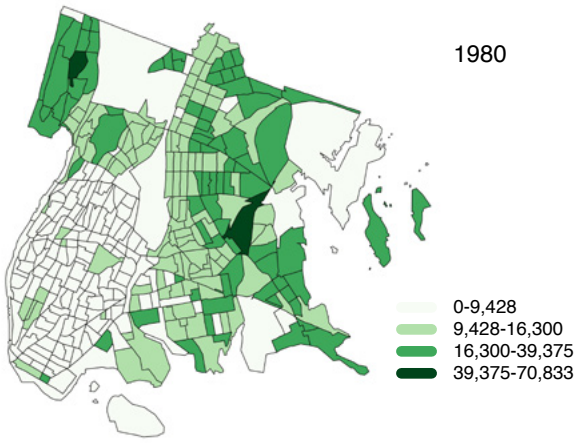
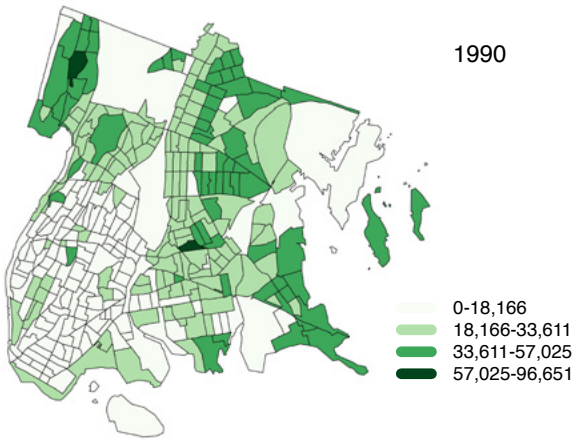
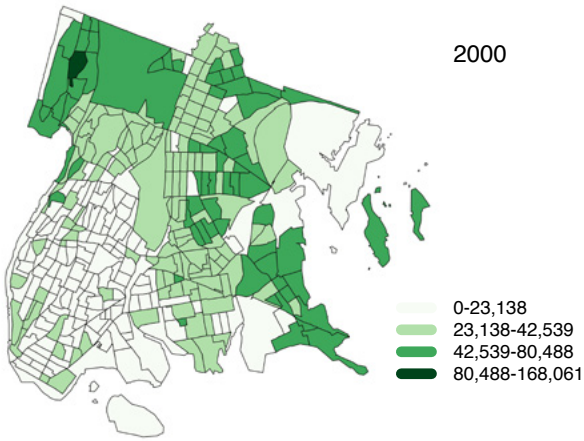


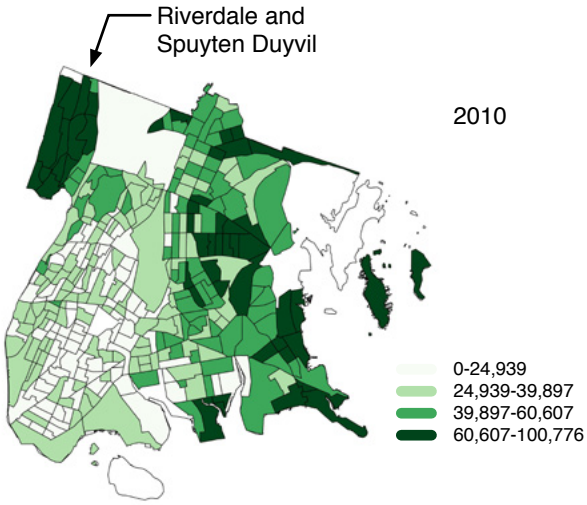
Figure 20 Analysis showing Bronx HOLC areas (A) and median household income* per census tract from 1950-2010, excluding 1960 and 1970
(continued on following page)
Image source: Author











*All values shown in USD, not adjusted for inflation

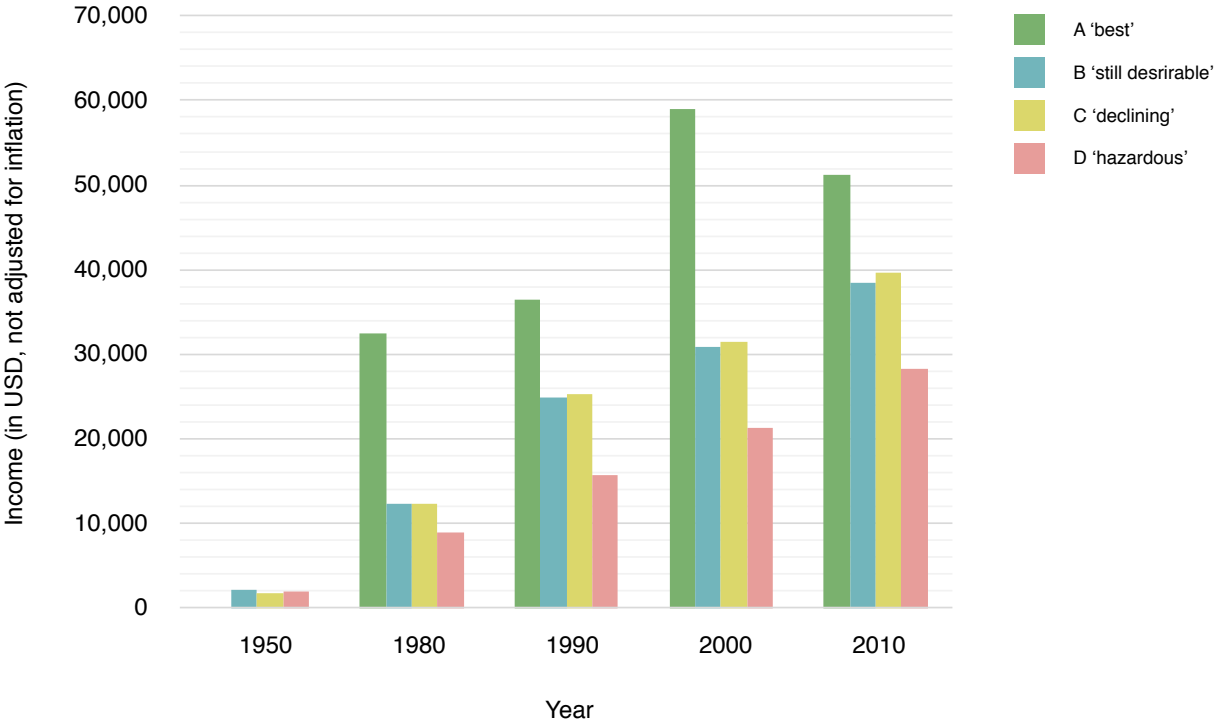


Figure 21 Average median household income per HOLC grading by decade
Image source: Author

This section has found a persistent correspondence over time between lower HOLC graded areas and census tracts containing majority percentage Black and Hispanic populations. High percentage Black census tracts were more consistently associated with D gradings, whereas Hispanic populations tended to be slightly more distributed throughout the B and C gradings. It has also shown a consistency over time of 'A (Best)' HOLC areas and higher income census tracts. These findings are consistent with those of Mitchell and Franco (2018) who suggest that, nationally, there is a 'pervasive, enduring structure of economic disadvantage in urban areas of the U.S.' and that the HOLC maps were 'part of a broad pattern of discriminatory practices in neighborhood lending risk assessment.' These quantitative results suggest that what was occurring on a national level was also occurring within the Bronx to a fairly large extent.

4.2 The Role of Street Configuration in Segregation

RESEARCH QUESTION TWO: To what extent, if any, does the contemporary street configuration reinforce or even strengthen the potential for natural movement throughout the Bronx and further isolate the HOLC lending areas from each other?

HYPOTHESIS: The changes which occurred between the historical and contemporary maps have strengthened the potential for through movement and therefore the extent to which the street network isolates the HOLC areas.

Figure 22 Historical street network shown at NACH RN with HOLC grading areas, same diagram as Figure 11 for reference
Image source: Author

HOLC AREA BOUNDARIES

This section will analyse the results from the methodology described in section 3.3. Figure 22 shows the same diagram as Figure 11: the historical analysed network at NACH RN with the HOLC grading areas (reproduced here for reference). Figure 23 shows the percentage change of averaged choice and integration values of each of the ten boundaries at the radii outlined in the methodology. Positive percentage changes indicate that the average values for a given boundary increased from the historical to contemporary condition, and negative numbers represent a decrease (more significant changes shown in bold). Firstly, it can be seen in the chart for percentage change of choice values that the more drastic changes (both negative and positive) occur at lower radii NACH R800 and R1000 with some values at -42% and -53%. There are also more significant changes at the global radius RN, though not as extreme with

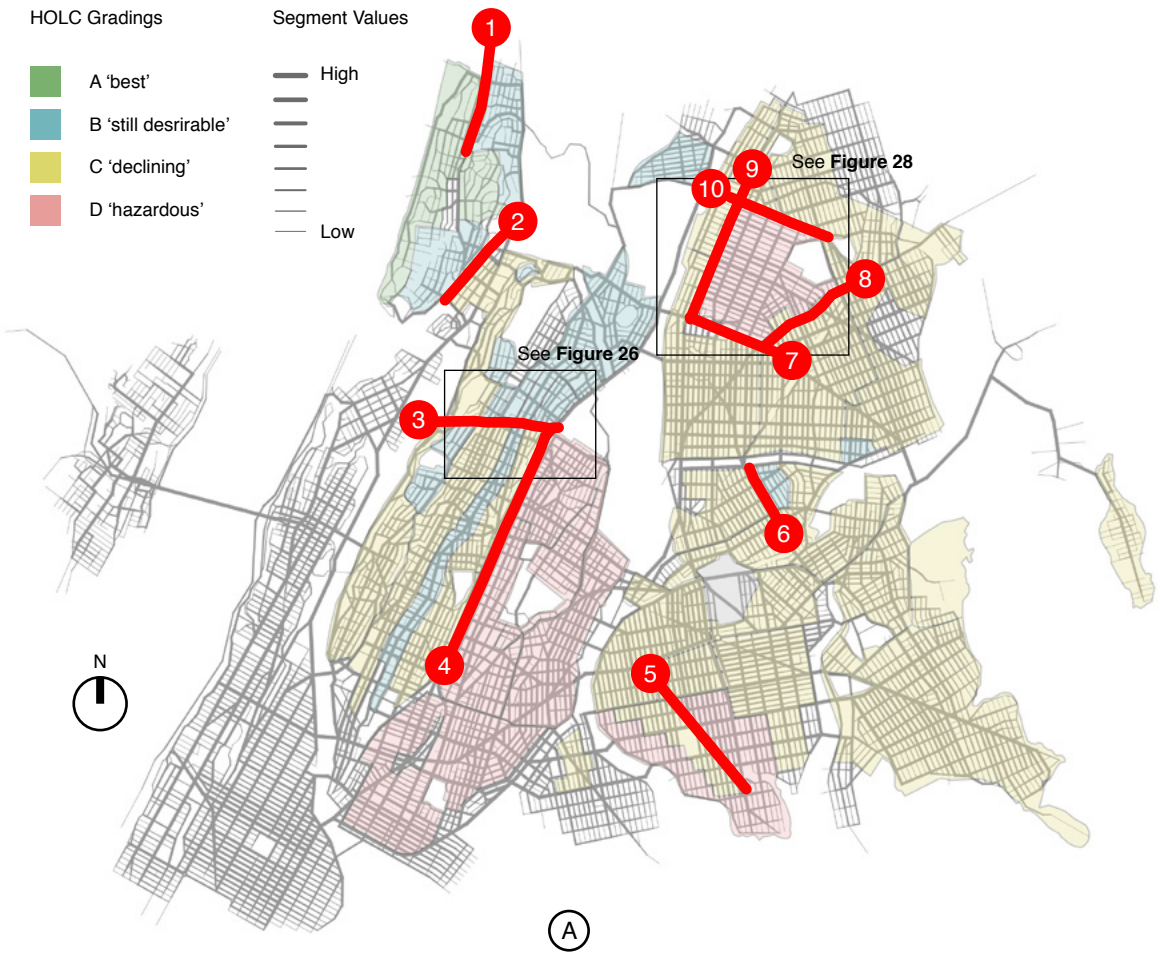
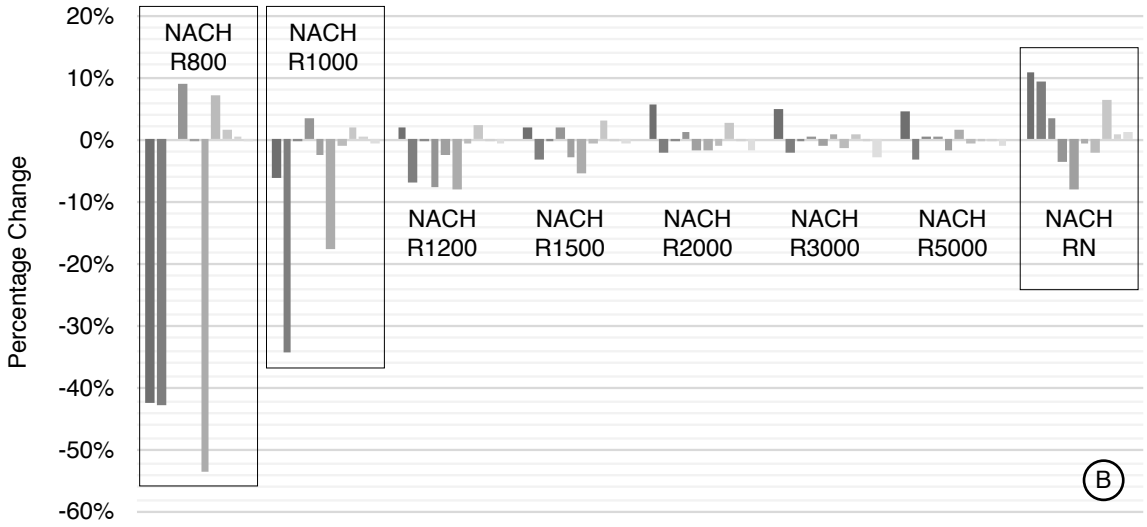


Figure 23 NACH RN analysis with HOLC grading areas and labelled study boundaries (A). Graphs showing percentage change of averaged choice (B) and integration (C) between historical and contemporary maps
Image source: Author

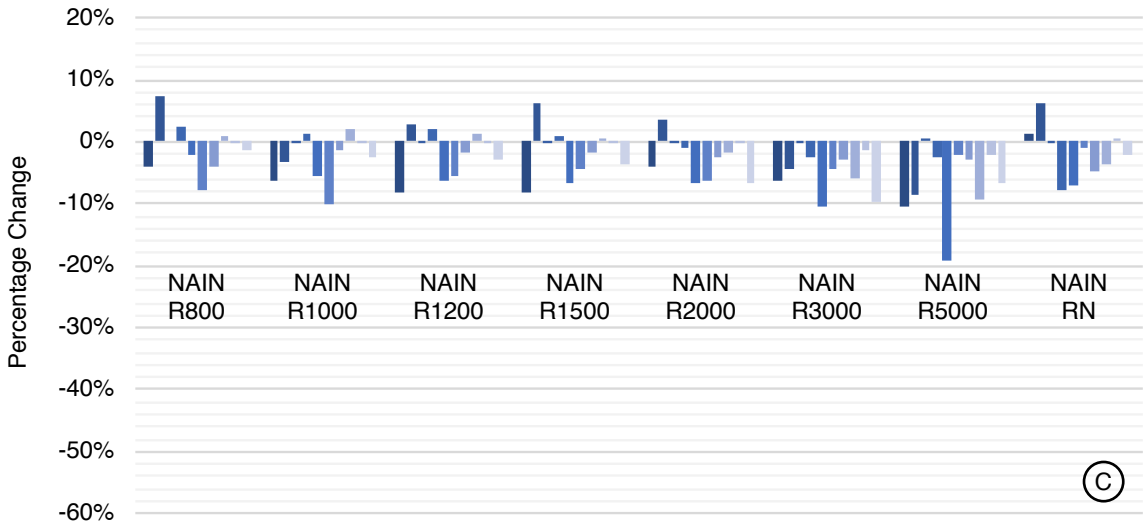
Percentage Change of Averaged Choice Values per Boundary

Boundary	NACH R800	NACH R1000	NACH R1200	NACH R1500	NACH R2000	NACH R3000	NACH R5000	NACH RN
1	**-42.5%**	-6.2%	2.0%	2.0%	5.6%	4.8%	4.3%	**10.7%**
2	**-42.6%**	**-34.1%**	-7.1%	-3.2%	-2.3%	-2.3%	-3.1%	9.3%
3	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.4%	3.5%
4	8.8%	3.3%	-7.8%	1.8%	1.0%	0.5%	0.0%	-3.6%
5	-0.3%	-2.4%	-2.6%	-2.7%	-1.6%	-0.9%	-1.8%	-8.1%
6	**-53.6%**	**-17.6%**	-7.9%	-5.5%	-1.6%	0.9%	1.7%	-0.5%
7	7.2%	-0.9%	-0.7%	-0.5%	-1.1%	-1.2%	-0.7%	-2.2%
8	1.7%	2.1%	2.4%	3.0%	2.5%	0.7%	-0.3%	6.5%
9	0.0%	0.1%	-0.1%	-0.1%	-0.1%	-0.3%	-0.4%	1.0%
10	-0.1%	-0.7%	-0.7%	-0.7%	-1.7%	-2.8%	-1.2%	1.1%



Percentage Change of Averaged Integration Values per Boundary

Boundary	NAIN R800	NAIN R1000	NAIN R1200	NAIN R1500	NAIN R2000	NAIN R3000	NAIN R5000	NAIN RN
1	-4.0%	-6.3%	-8.1%	-8.0%	-3.9%	-6.3%	-10.5%	1.4%
2	7.4%	-3.3%	2.7%	6.1%	3.5%	-4.5%	-8.5%	6.1%
3	0.0%	-0.1%	-0.2%	-0.2%	-0.2%	0.0%	0.7%	-0.2%
4	2.4%	1.4%	2.0%	0.9%	-0.9%	-2.4%	-2.4%	-7.7%
5	-2.0%	-5.6%	-6.1%	-6.7%	-6.7%	**-10.5%**	**-19.1%**	-6.9%
6	-7.6%	-9.9%	-5.5%	-4.5%	-6.1%	-4.3%	-2.1%	-1.2%
7	-3.8%	-1.4%	-1.7%	-1.8%	-2.5%	-2.8%	-2.7%	-4.8%
8	1.1%	2.2%	1.2%	0.5%	-1.6%	-5.8%	-9.3%	-3.7%
9	-0.1%	-0.1%	-0.1%	-0.2%	-0.3%	-1.2%	-2.1%	0.7%
10	-1.5%	-2.3%	-2.9%	-3.7%	-6.6%	-9.7%	-6.5%	-2.1%



some values around 10%. All other radii show very small changes under 5-10%. Now looking at the chart for percentage change of integration values, it is noted that almost all radii, except for one case of 19% at NAIN R5000, are consistently below 10%. These data reveal that the changes which occurred between the historical and contemporary conditions were the most drastic at local and global radii choice values, with fairly large percentage decreases in local conditions. As mentioned previously, choice is the measure of 'through movement' from 'everywhere to everywhere else' (B. Hillier 1996b, 127), so it is sensible to deduce from these results that the potential for through movement was the most significantly affected between the historical and contemporary conditions at local and global radii, and relatively unaffected at radii in between.

STANDARD DEVIATION ANALYSIS

The next analysis tested the standard deviation of choice and integration values among the segments making up each of the ten boundaries between HOLC areas in both the historical and contemporary maps. These results are graphed in Figure 24, and it can be observed that the standard deviation values decrease as the radii increase for both the historical and contemporary conditions. This reveals that the values of the segments are more consistent at global scales of analysis. Further, it is seen that the local measures for choice—NACH R800 and R1000—in the historical and contemporary conditions have relatively large deviations (see highlighted areas in the graphs). This simply means that there are inconsistent values among the segments of the boundaries at these radii. Recalling the previous analysis of the HOLC area boundaries, these large deviations in the NACH R800 and R1000 most likely account for the high percentage change values noted in Figure 23. Additionally, many of these boundaries dividing the HOLC areas are longer than 1000m, so it is sensible that a high amount of variation would exist among the segments that comprise the boundaries. This same phenomenon is also noted for the standard deviation of the integration values, however, as was noted in the previous analysis, the percentage changes from historical to contemporary conditions were not as significant.

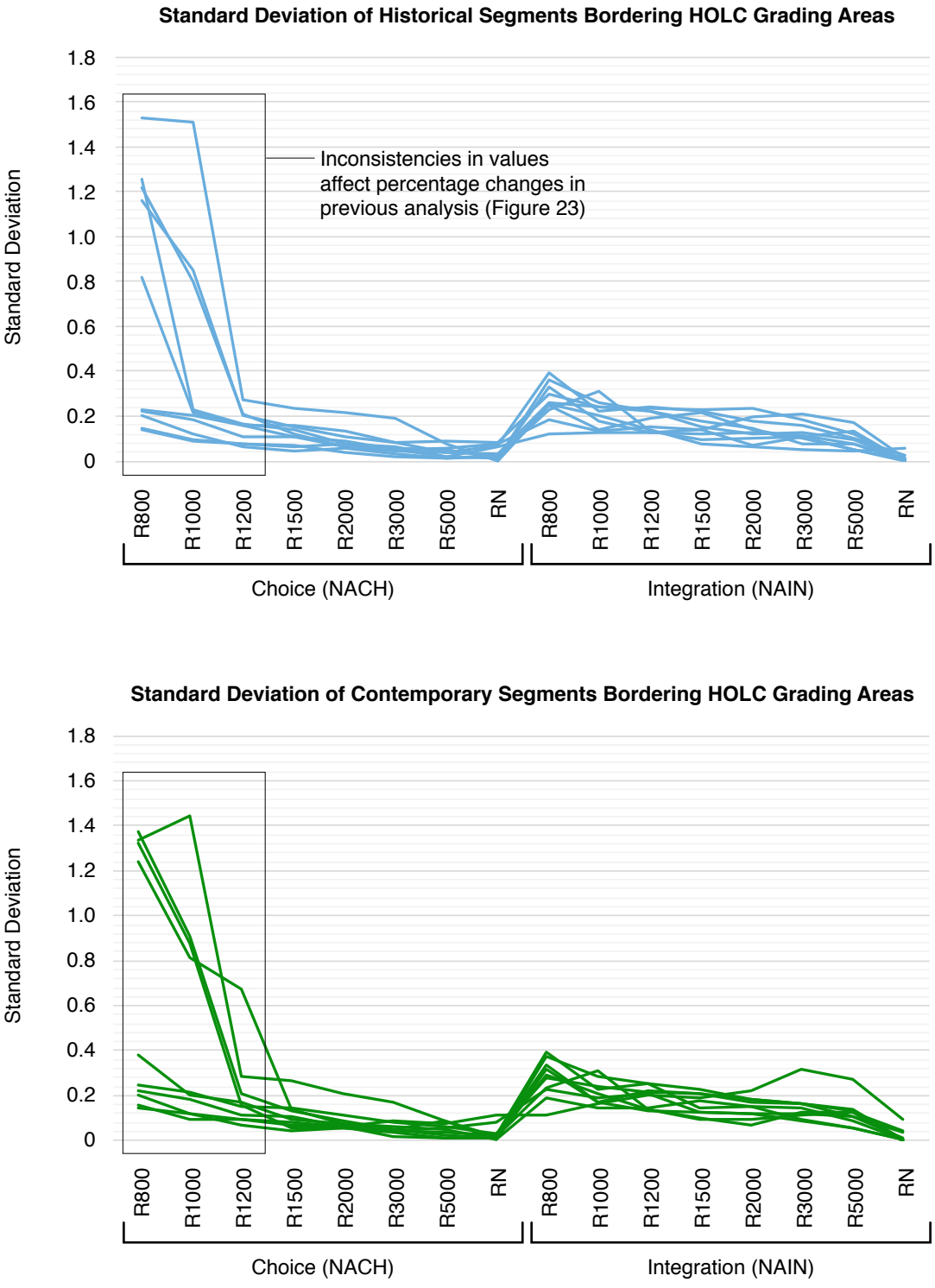


Figure 24 Standard deviation values of choice and integration decrease as radii increase in both historical and contemporary conditions

Image source: Author

HOLC GRADINGS AND STREET CONFIGURATION

This section will attempt to understand the reasoning for some of the HOLC lending risk gradings and the relationship to the street configuration. Recalling Figure 11 which highlights the area graded ‘B (Still Desirable)’ along the length of Grand Concourse and surrounded by ‘C (Declining)’ areas, an historical account reveals that the Grand Concourse was a widely celebrated boulevard lined with marble Art Deco buildings. Rosenblum (2009) notes that the Grand Concourse was like the ‘Champs-Élsées of the Bronx…the ultimate prestige address for vast numbers of the city’s upwardly mobile Jews’. Figure 25 shows a drawing of the Concourse as a wide, tree-lined boulevard, and it is not difficult to imagine that the lending institutions would have known about this street’s reputation which would consequently be reflected in the higher grading of the HOLC map. As mentioned in the methodology, this B grading surrounded by C graded areas recalled the principle of marginal separation by linear integration, and the following analysis will explore this principle as outlined previously.

In Figure 26, the area west of Fordham University is shown in the historical and contemporary conditions at NACH R5000. The same numbering system as the HOLC area boundary analysis

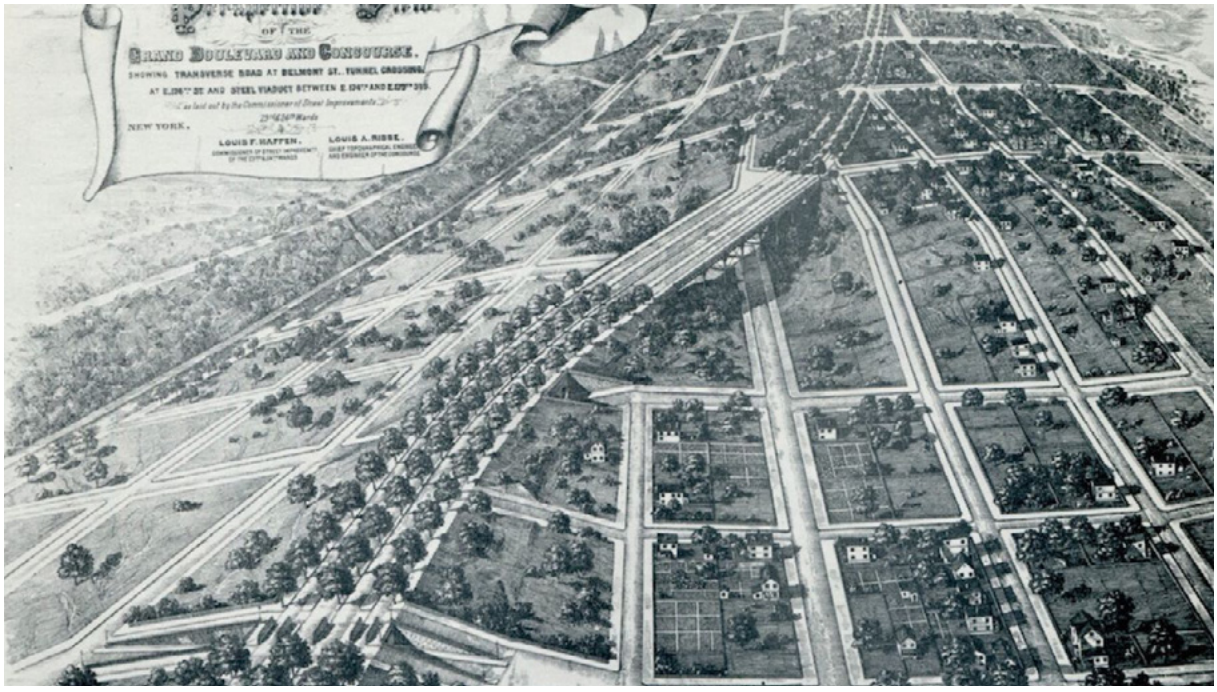


Figure 25 Artist’s drawing of the Grand Concourse as a wide, tree-lined boulevard
Image source: *AM New York*

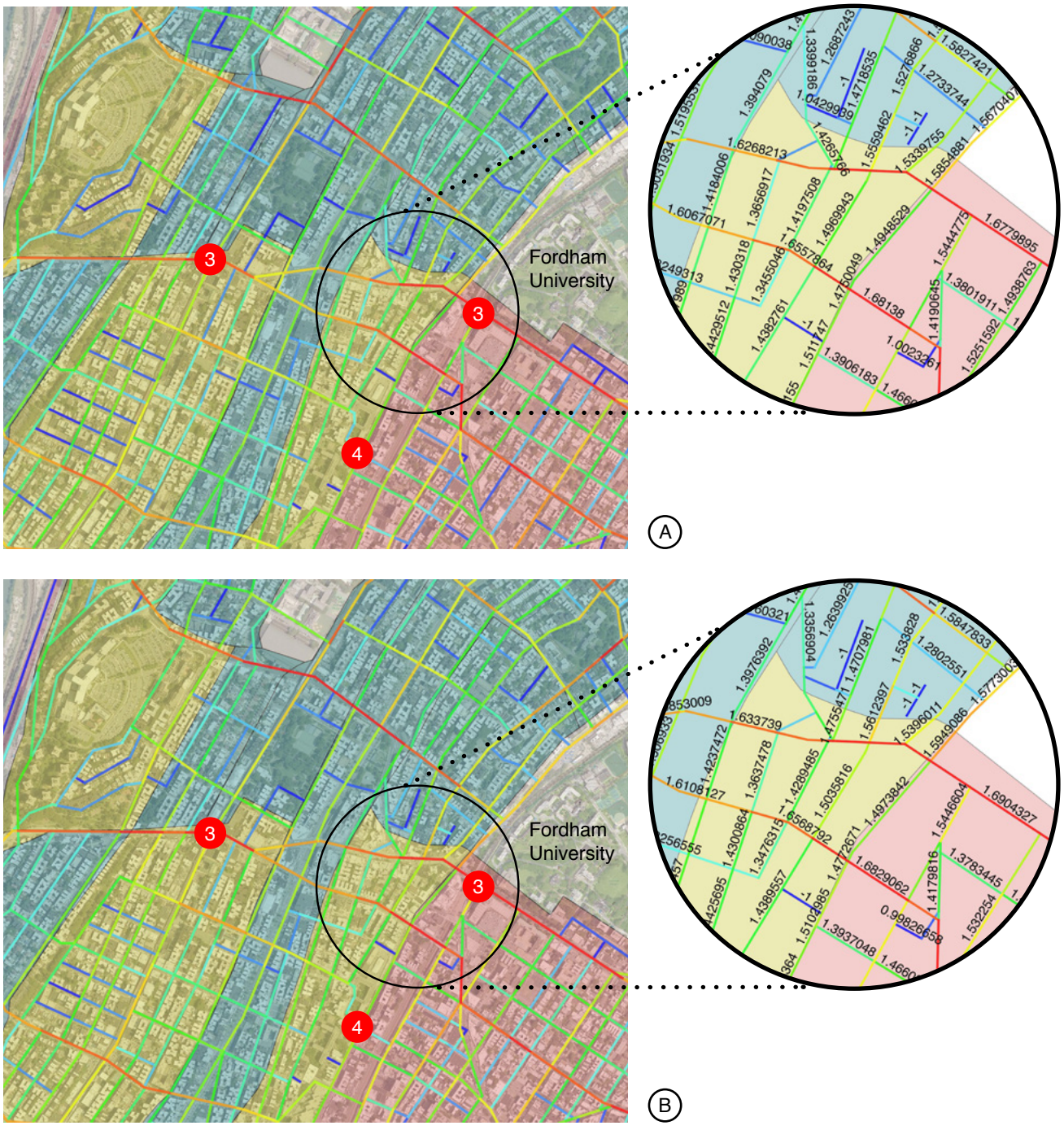


Figure 26 Enlarged area west of Fordham University showing historical (A) and contemporary (B) NACH R5000 conditions

Image source: Author

was used, and the larger map in Figure 23 can be used for reference. It can be observed that there is a general consistency of higher choice values along the length of segment 3 with several street segments perpendicular with lower values. However, segment 4 seems to be a different case, where, even though there is consistency along the length of the segment, there does not seem to be much change in the perpendicular segments along it. In comparing the two areas in the enlarged callouts labelled with segment values, there does not seem to be a significant change between the historical and contemporary conditions. This suggests that marginal separation is only slightly occurring here, and that the value of these segments has remained relatively consistent throughout time. However, if the same area is observed at NACH RN in Figure 27, it is seen that segment 4 has a higher global value, especially compared with the segments perpendicular to it. This shows that segment 4 is perhaps a marginal separator in the global network. Additionally, it is noted here that Grand Concourse also shows a relatively high global choice value.

Figure 28 shows the area east of Woodlawn Cemetery in a similar way to the analysis in Figure 26 with NACH R5000 historical and contemporary conditions. Here it is seen that there is a similar consistency of values along the length of segments 7-10 and a decrease especially

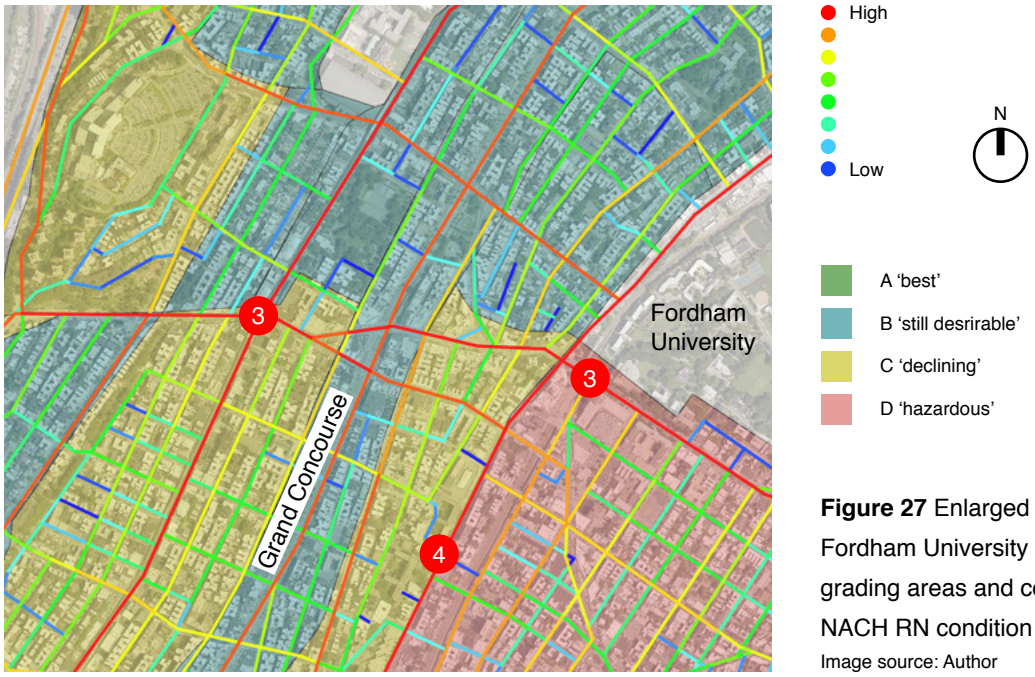


Figure 27 Enlarged area west of Fordham University with HOLC grading areas and contemporary NACH RN condition
Image source: Author

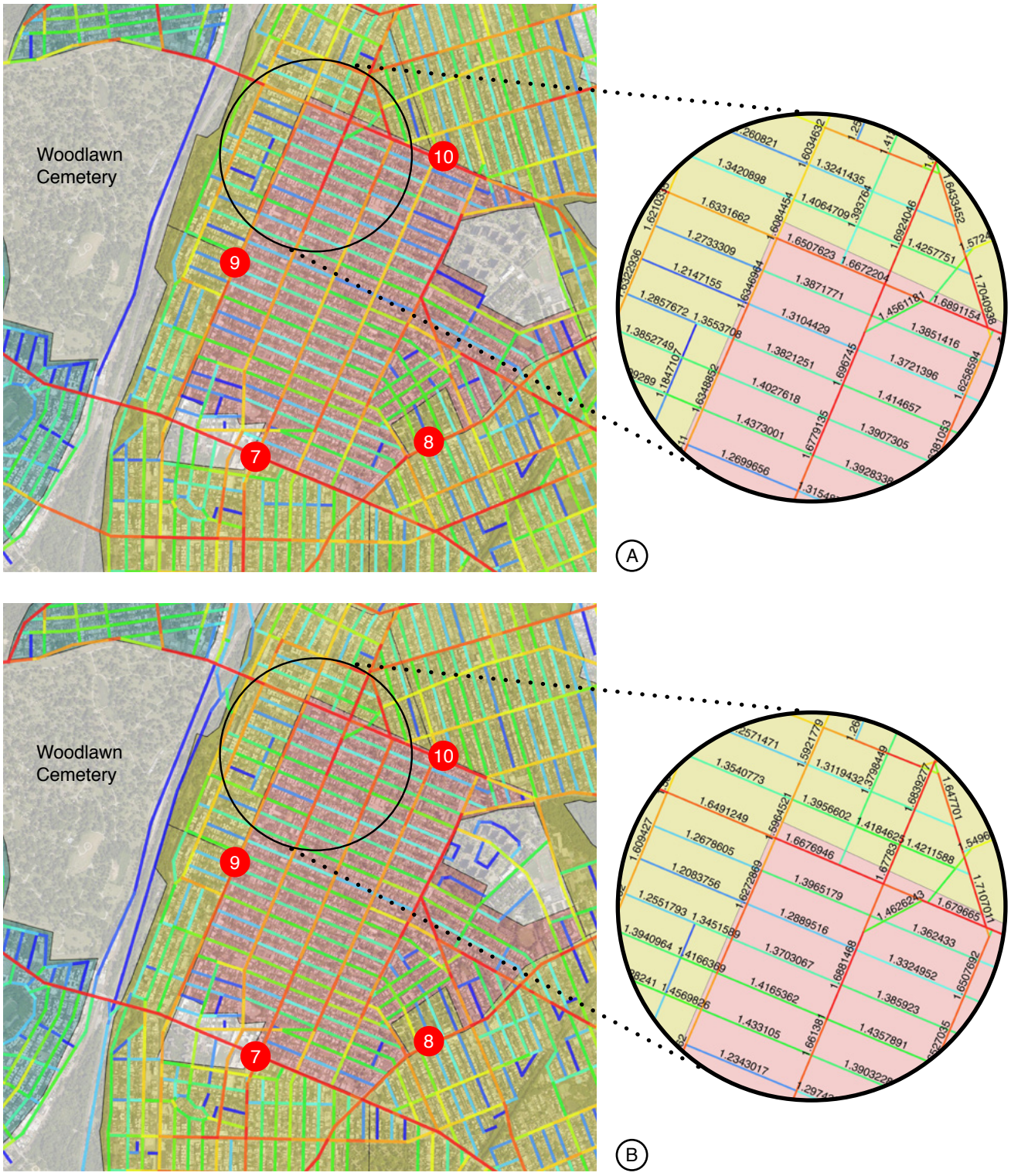


Figure 28 Enlarged area east of Woodlawn Cemetery showing historical (A) and contemporary (B) NACH R5000 conditions

Image source: Author

in the perpendicular segments running east/west between the C and D graded areas. Another brief observation to note is the ‘C (Declining)’ area adjacent to Woodlawn Cemetery. It is likely that when the HOLC map was drawn, areas surrounding green or open space was seen as slightly more desirable than the ‘D (Hazardous)’ areas, and this condition may reveal that the cartographers left a ‘buffer’ of sorts around the green space. Furthermore, this ‘buffer’ can be seen also in the 2010 census tract data (which can be recalled from section 4.1) where the percentage Black population showed a distinct concentration in this area (Figure 29). It seems that segments 7, 9, and 10 also serve as divisions between census tracts, and they have potentially aided in reinforcing the racial makeup to a fairly large extent.

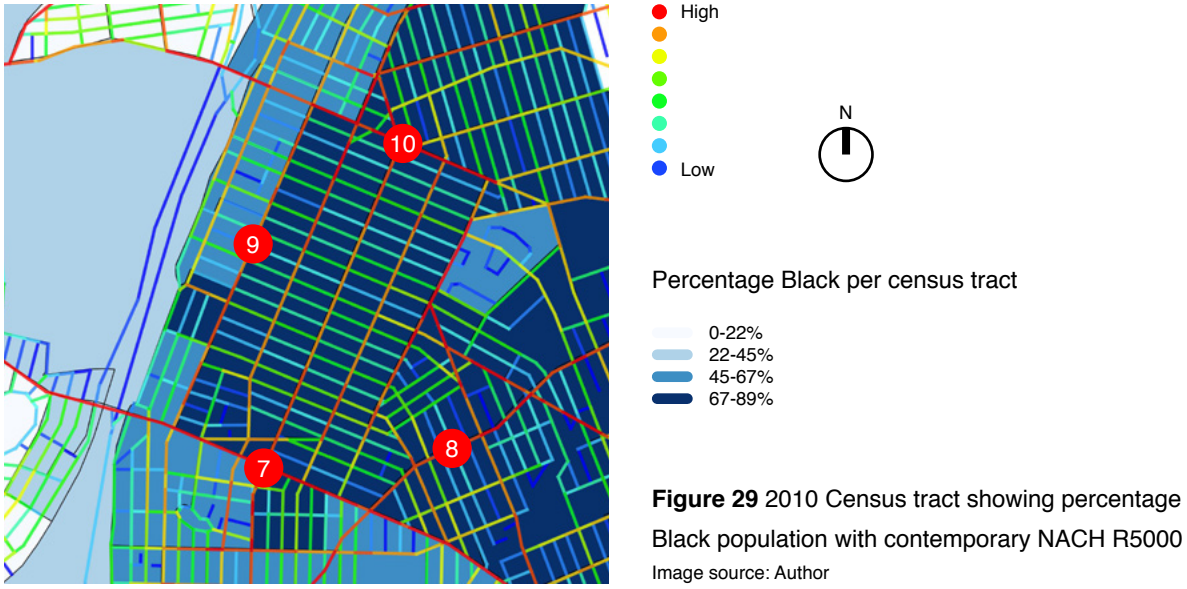


Figure 29 2010 Census tract showing percentage Black population with contemporary NACH R5000
Image source: Author

To conclude, the phenomenon of marginal separation by linear integration does occur to some extent in the study areas, as several of the segments showed abrupt decreases of choice values in segments perpendicular to main roads (high choice value streets). This pattern is most apparent at global scales of analysis, as was the consistency of values along the length of the study boundaries from the standard deviation analysis. The changes from historical to contemporary conditions were not significant in the boundary analysis, the standard deviation test, or the marginal separation analysis.

4.3 The Impact of the Cross-Bronx Expressway

RESEARCH QUESTION THREE: What were the long-term spatial effects of the Cross-Bronx Expressway's construction on the local movement network?

HYPOTHESIS: The severance caused by the Expressway affected the values of the local movement network, and as the radius increases, the changes lessen, especially at the edges of the study area.

This section will look more closely at the portion of the Cross-Bronx Expressway and the study area outlined in section 3.4. Figure 30 shows the study area and highlights the segments that were modified as a result of the construction of the Expressway. Some segments were shortened or removed, as mentioned previously, while others were added, including access roads to the Expressway itself. It is important to note that there were changes to street segments which are not adjacent to the Expressway, seen in Figure 30 to the north and south.

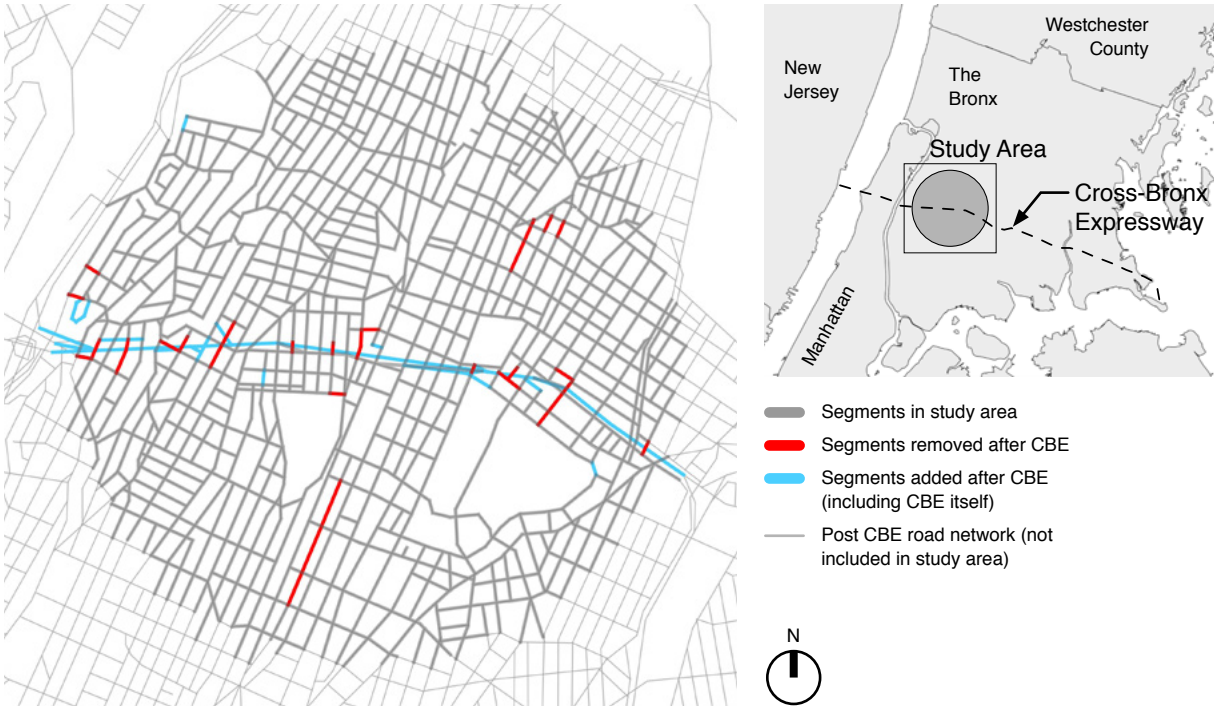


Figure 30 Study area around Cross-Bronx Expressway with affected street segments
Image source: Author

CHOICE ANALYSIS PERCENTAGE CHANGE

Figure 31 shows the percentage change for normalised choice values, colouring the segments from dark red to dark blue indicating percentage decrease and percentage increase from historical to contemporary conditions, respectively. The light colours in the middle (closer to white) indicate that very small or no percentage changes occurred. The diagram showing affected segments from the previous figure is reproduced here for reference, and it is seen that the segments which were severed by or adjacent to the Expressway are affected more than the surrounding segments. It should be noted that some of the percent decreases are relatively extreme, with some as much as -299%. This seems somewhat obvious, given that many of these segments changed from continuous streets to dead ends, or they were eliminated completely in some cases. Finally, in comparing all the radii together, there seems to be very little difference as the scale of analysis is increased.

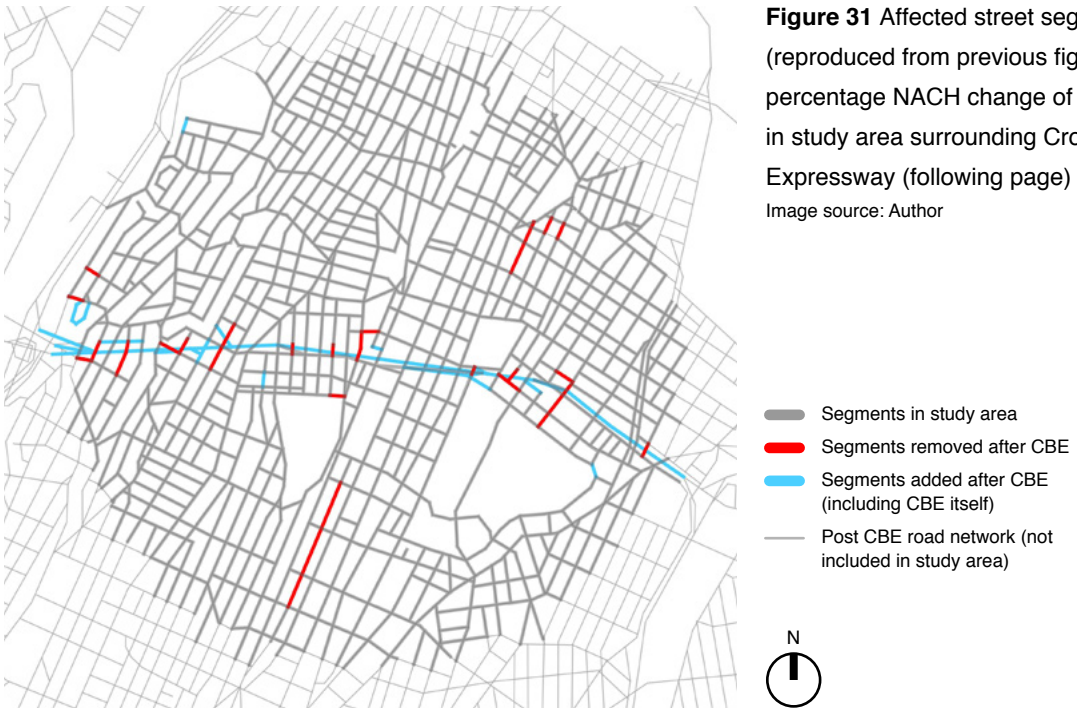
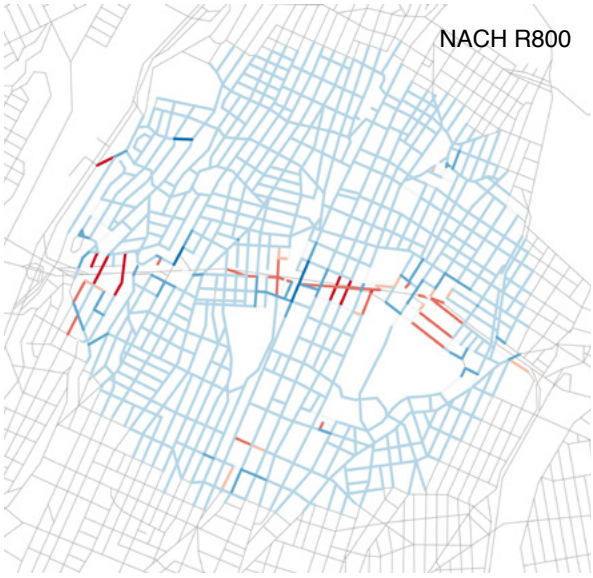
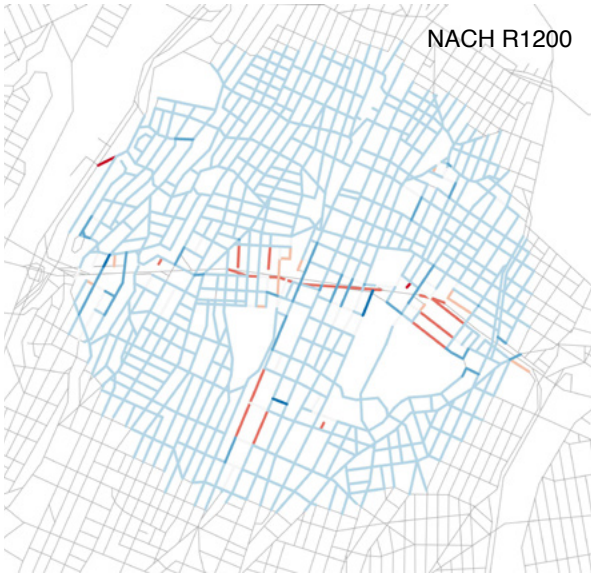


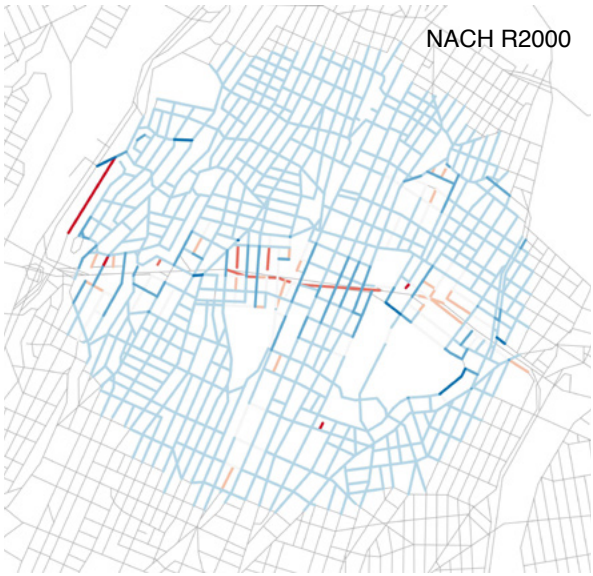
Figure 31 Affected street segments (reproduced from previous figure) and percentage NACH change of segments in study area surrounding Cross-Bronx Expressway (following page)
Image source: Author



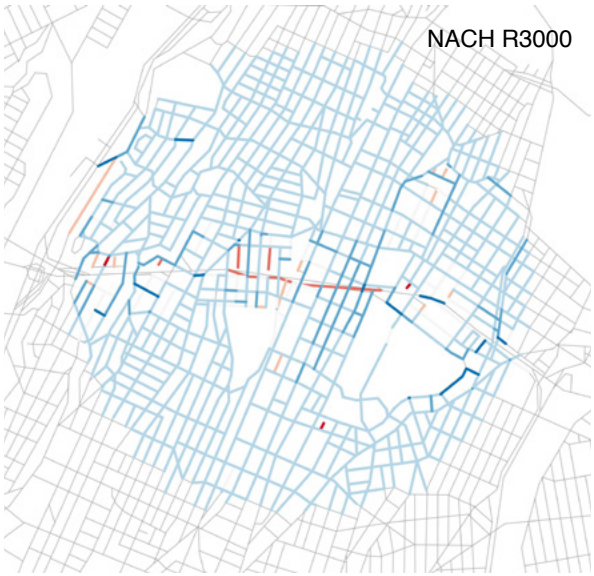
-299 -> -213%
-213 -> -155%
-155 -> -21%
-21 -> -5%
-5 -> +7%
+7 -> +40%
+40 -> +104%



-265 -> -213%
-213 -> -156%
-156 -> -24%
-24 -> -5%
-5 -> +8%
+8 -> +48%
+48 -> +109%



-256 -> -206%
-206 -> -160%
-160 -> -15%
-15 -> -3%
-3 -> +4%
+4 -> +18%
+18 -> +49%



-253 -> -214%
-214 -> -160%
-160 -> -21%
-21 -> -5%
-5 -> +3%
+3 -> +15%
+15 -> +41%

INTEGRATION ANALYSIS PERCENTAGE CHANGE

Now looking at Figure 32 with the percentage change of integration values, it can be seen that the changes (both increases and decreases) tend to occur closer to the Expressway just as observed in the choice analysis. However, in this case, it seems that there are more segments further away from the Expressway that have shown changes, and there is also a greater variation of changes among the 4 studied radii. In fact, as the radius increases, it seems that there are more changes at greater distances from the Expressway. This could be a result of other factors not associated with the Expressway, for example, in the affected segments diagram reproduced from Figure 30, it is seen that the segments within the areas marked ‘A’ and ‘B’ have an effect on those analogous locations in the percentage change diagrams, notably at R1200 and R2000. To analyse these affected segments farther from the Expressway, the locations of New York City Housing Authority (NYCHA) buildings were also compared with the street network. It is seen that within the areas marked ‘A’ and ‘B’ there are NYCHA buildings, and both areas correspond with segments removed shown in red. Therefore, two of the factors affecting the integration values are the addition of the Cross-Bronx Expressway and the various public housing that was built since the time of the historical map.

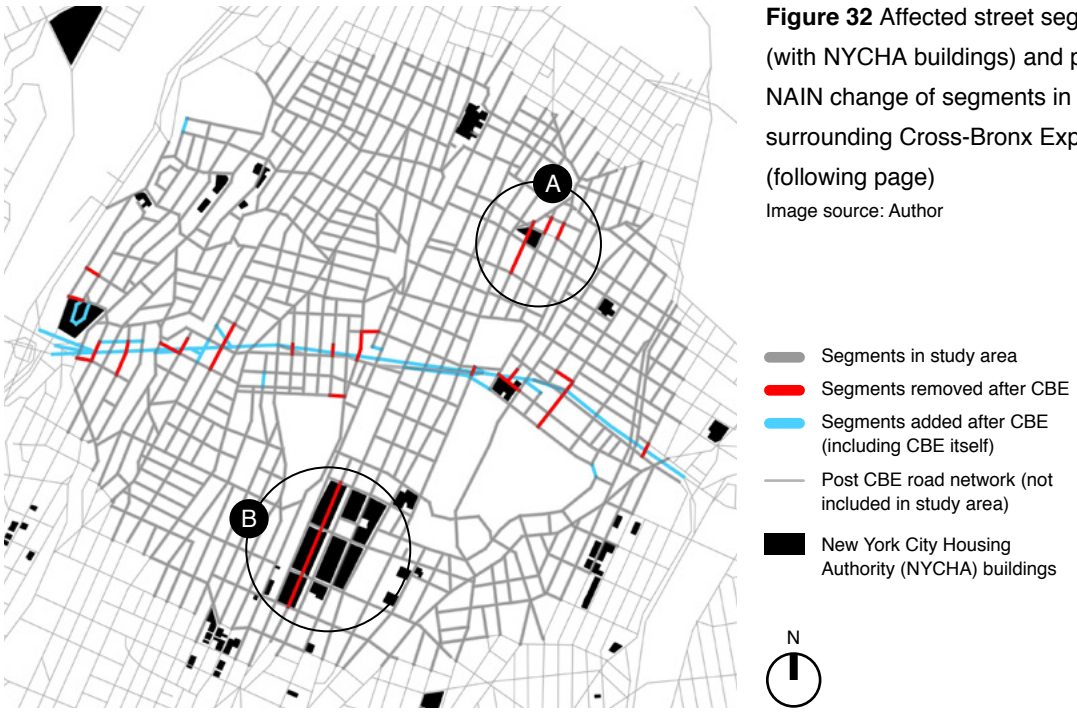
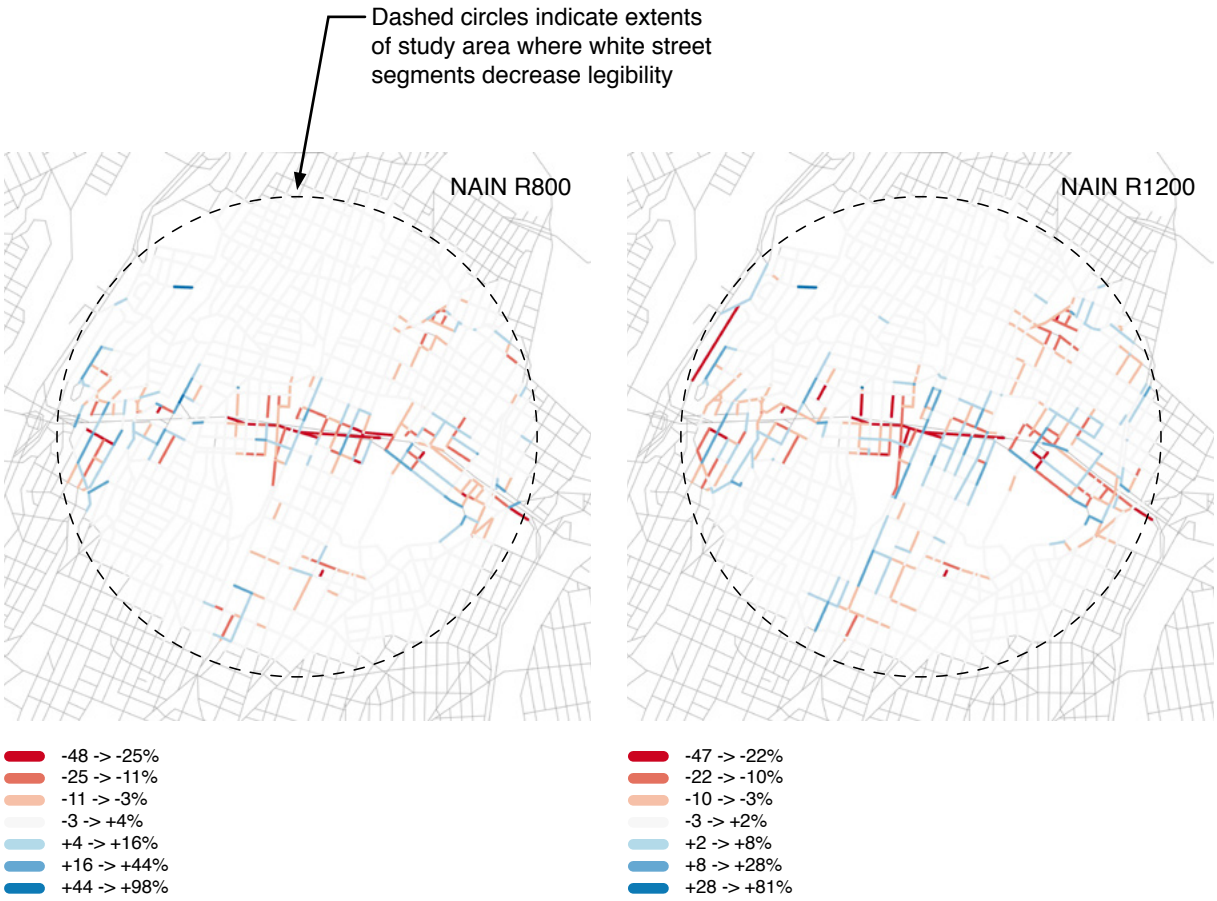
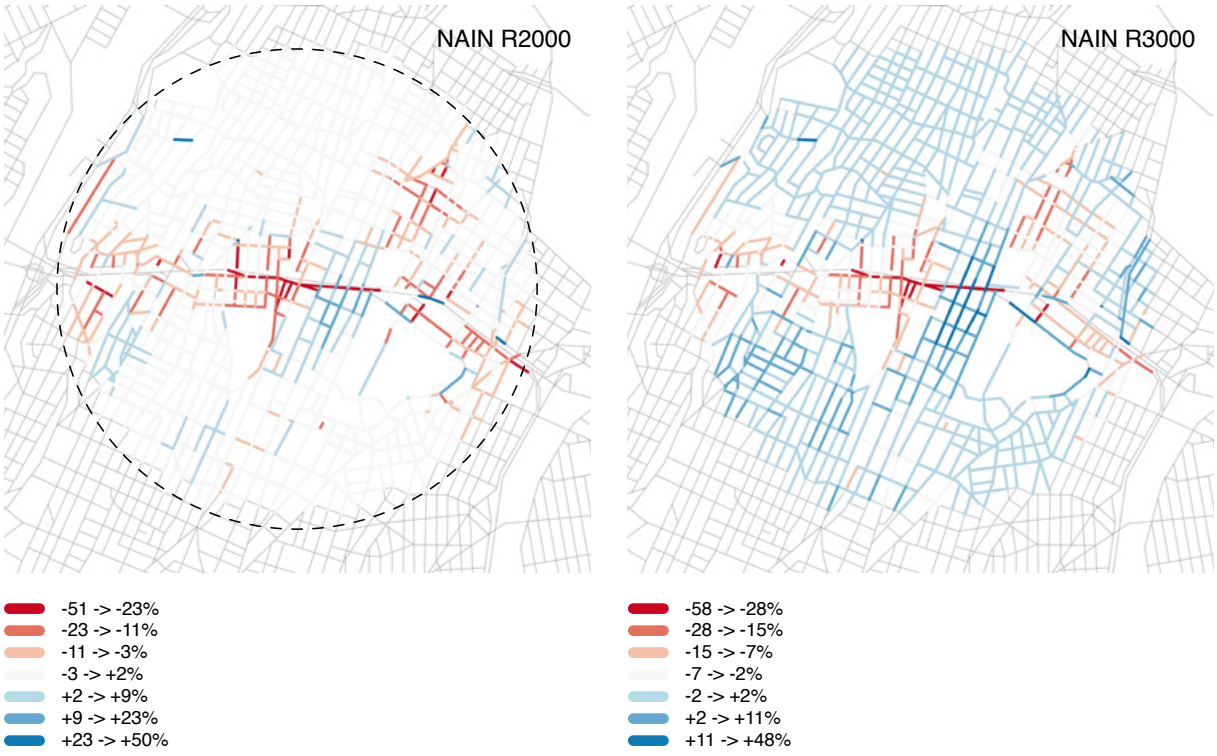


Figure 32 Affected street segments (with NYCHA buildings) and percentage NAIN change of segments in study area surrounding Cross-Bronx Expressway (following page)
Image source: Author

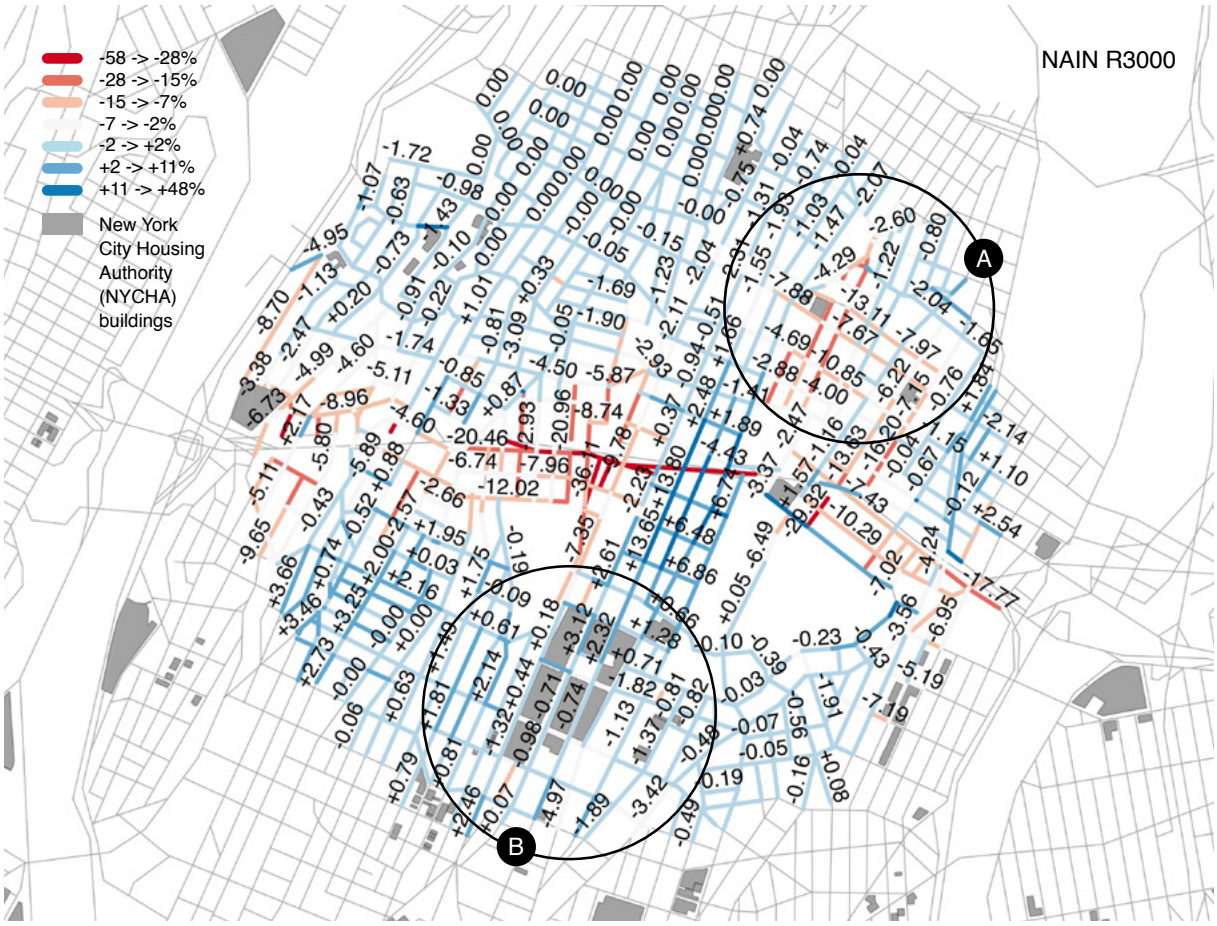

Dashed circles indicate extents
of study area where white street
segments decrease legibility
NAIN R800
NAIN R1200
-48 -> -25%
-25 -> -11%
-11 -> -3%
-3 -> +4%
+4 -> +16%
+16 -> +44%
+44 -> +98%
-47 -> -22%
-22 -> -10%
-10 -> -3%
-3 -> +2%
+2 -> +8%
+8 -> +28%
+28 -> +81%

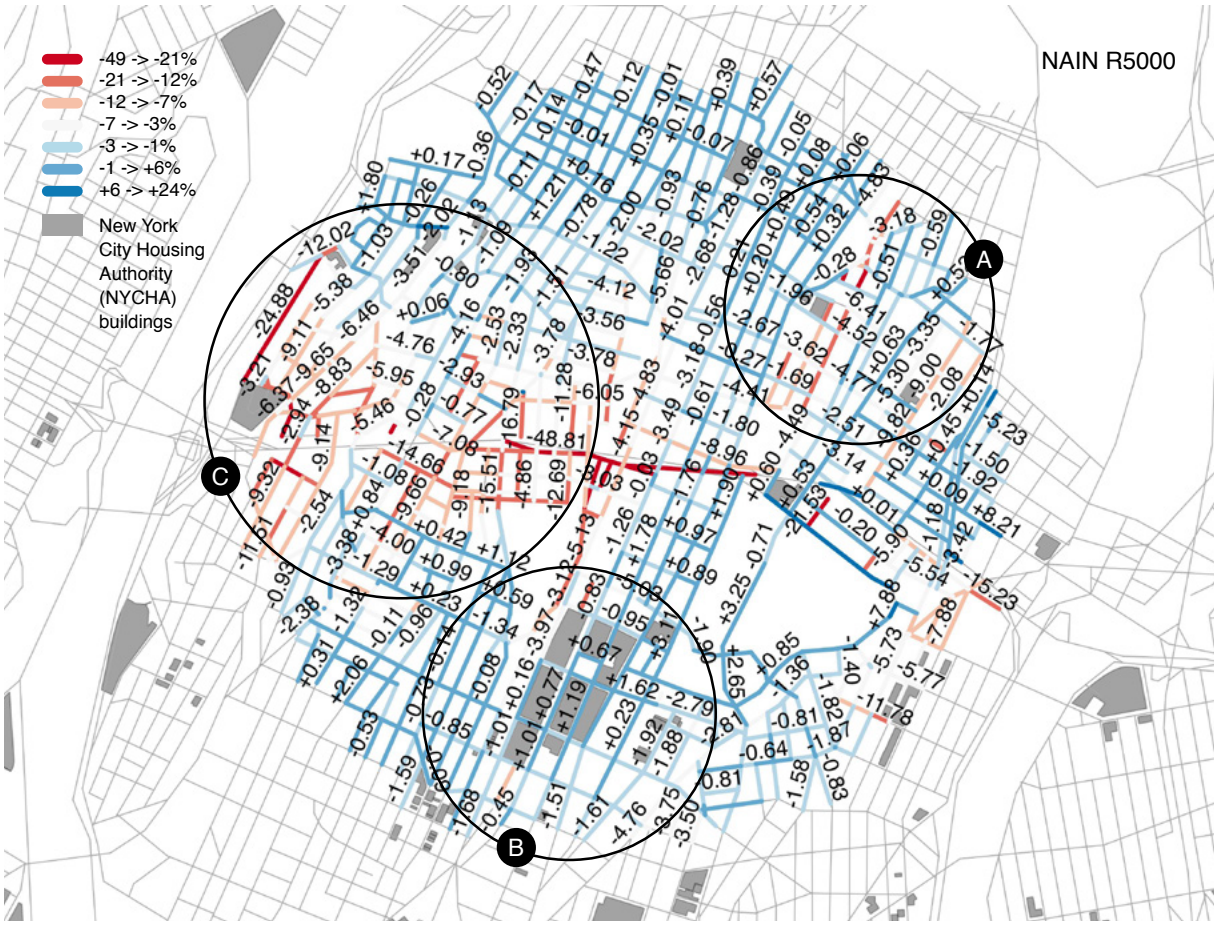

NAIN R2000
NAIN R3000
-51 -> -23%
-23 -> -11%
-11 -> -3%
-3 -> +2%
+2 -> +9%
+9 -> +23%
+23 -> +50%
-58 -> -28%
-28 -> -15%
-15 -> -7%
-7 -> -2%
-2 -> +2%
+2 -> +11%
+11 -> +48%

Observing that the changes occurred farther from the expressway at higher radii, it was worth studying the NAIN R2000 and R3000 closer, as well as adding R5000 and RN to the analysis. In Figure 33, the study area at these radii are shown at a larger scale and their percentage change values are labelled. The locations of the NYCHA buildings are also indicated, as it was observed previously that these locations corresponded with some removed segments within the study area which would have an effect on the percentage change values. At R2000 it is seen that there are decreases between 0-51% adjacent to the Expressway and decreases as high as 35% near the NYCHA building within circle ‘A’. Within the circle marked ‘B’, there is almost no change (values less than 2%), and at R3000 and R5000 they remain at nearly 0%. The changes within circle ‘A’ become less significant at R3000 and R5000, showing values at -20% and -15%, respectively. However, it is observed in circle ‘C’ closer to the Expressway that higher percentage decreases begin occurring at R5000. Finally, looking at NAIN RN in

Figure 33 Enlarged study areas showing NAIN R2000, 3000, 5000 and N with percentage change values (continued on following pages)

Image source: Author


-58 -> -28%
-28 -> -15%
-15 -> -7%
-7 -> -2%
-2 -> +2%
+2 -> +11%
+11 -> +48%
New York City Housing Authority (NYCHA) buildings
NAIN R3000
A
B


-49 -> -21%
-21 -> -12%
-12 -> -7%
-7 -> -3%
-3 -> -1%
-1 -> +6%
+6 -> +24%
New York City Housing Authority (NYCHA) buildings
NAIN R5000
A
B
C

this figure, a few more changes are seen. More significant decreases of 5-15% begin to occur at the southern portion of the study area. These changes are likely due to other influences within the wider network of the Bronx as a whole. The other noticeable difference here is the emergence of decreased values along Webster Avenue running north/south (labelled 'D'). The reader may recall from section 4.2 that this segment (number 4 in Figures 26 and 27) also showed distinct changes at the global (n) scale compared with the segments surrounding it. It should be pointed out that overall, the changes to the integration values are much smaller than the changes seen in the choice analysis. The largest decrease was 50% and the highest increase was around 100%, and this range decreased to -23-45% at global scale.

A final observation that is worth noting regarding the Cross-Bronx Expressway is the fact that this piece of infrastructure seemed to have an impact on the census tracts from section 4.1. A brief look at Figure 34 will reveal that between 1950 and 1960—the period when the

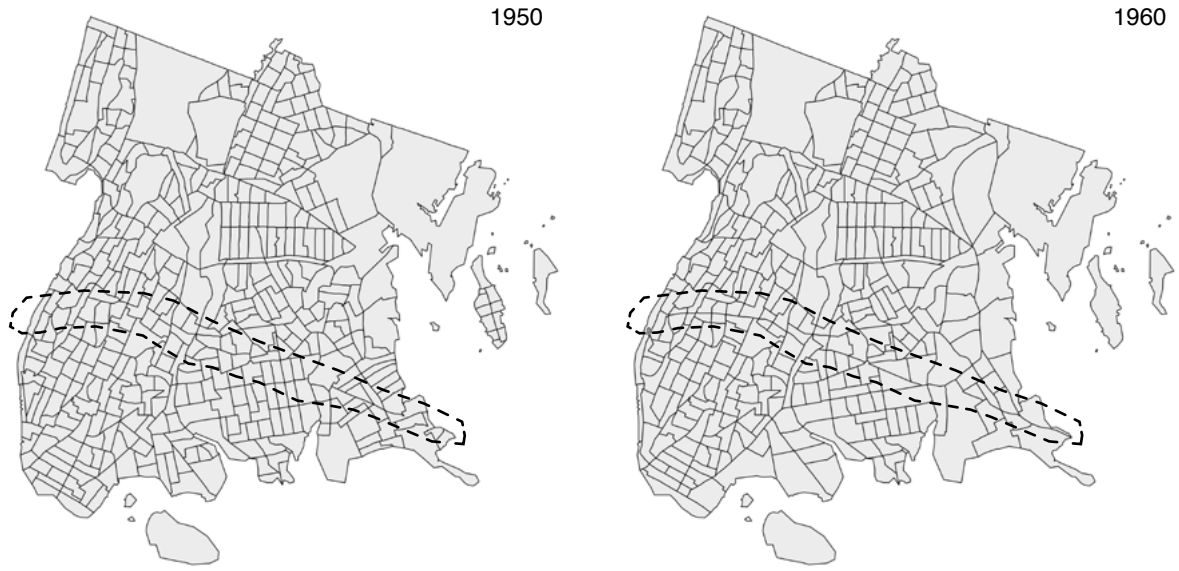


Figure 34 Bronx County census tracts in 1950 and 1960 showing the separation by the Cross-Bronx Expressway
Image source: Author

Expressway was built—there are divisions within the census tracts at the exact location of the Expressway's path. Census tracts in the United States not only reveal information about a population, but they also form the basis of allocation of public resources and funding. Therefore, it may be said from the percentage change analysis and this observation about the division of the census tracts that the Cross-Bronx Expressway carried not only spatial but administrative effects on the borough.

Chapter 5: Conclusion and Discussion of Findings

5.1 Research Overview

This research has looked at the demographics and morphology of the Bronx to better understand the persistent socio-economic and racial segregation within the borough and its relationship to the movement network. First, it used decennial census data to analyse Black and Hispanic populations, as well as household income, against the HOLC lending map of the Bronx. The study found that the discriminatory lending practices shown in the HOLC map formed the foundation for long-term segregation that still exists today. Areas which were considered 'C (Declining)' and 'D (Hazardous)' during the 1930s are now largely concentrations of Black and Hispanic populations, and conversely, areas considered 'A (Best)' are home to some of the highest median incomes in the borough.

The study also compared the analysed street network with the HOLC map to better understand the locations and rationale for some of the lending risk areas. This analysis showed that street segments with high global choice values tended to form the 'borders' of the HOLC grading areas, and a standard deviation analysis showed that the values among each tested segment tended to be more consistent as the radius of analysis increased. In an analysis of two smaller areas (one west of Fordham University and the other east of Woodlawn Cemetery), it was found that streets with high choice values that bordered the HOLC areas often had higher values than streets perpendicular to them. This indicated that the potential for through movement was higher at the borders of the various lending areas as opposed to the streets one step away from them. This pattern was most pronounced at global radii, and it persisted over time despite changes to the movement network.

Finally, the research concluded with a consideration of the Cross-Bronx Expressway as a mechanism of spatial severance within the movement network. It was revealed that the Expressway affected the choice and integration values of surrounding streets. Changes in segments adjacent to the Expressway were seen for choice measures, and there was very

little difference between the various radii. Changes farther from the Expressway were seen for integration measures, and this was partly due to NYCHA buildings which also caused changes to the street network. Further, there were more noticeable changes seen between the studied radii for integration. These findings, combined with the demographic and spatial network analyses, revealed that the Bronx has been transformed significantly by top-down forces over time. Discriminatory lending guided by the natural boundaries of the street network (in addition to the development of the surrounding suburbs) has siloed Black and Hispanic populations within pockets of the borough, and the Cross-Bronx Expressway has altered the movement network both spatially and administratively.

5.2 Demographics and Persistent Segregation in the Bronx

The hypothesis for the first research question was found to be correct: the lending practices outlined in the HOLC map created the conditions for persistent racial and socio-economic segregation. This pattern is consistent with the study by Mitchell and Franco (2018) which found a high correspondence nationally between HOLC graded areas, race, and wealth. As noted previously in the literature review, segregation is a complex urban phenomenon, and it is not easy to define. The type of segregation seen in the Bronx has more to do with housing policies and economic status as mentioned by Rokem and Vaughan (2018), rather than the way B. Hillier et al. (1993) describe it as a measure of access to a movement network. The discriminatory lending carried out during the 20th Century has greatly contributed to segregation and the exclusion of many Black Americans from owning property and taking part in the middle class. Described previously by Rothstein (2017), these lending practices were not merely oversights but rather ‘scores of racially explicit laws, regulations, and government practices’ (ibid, xii).

The hypothesis for research question two was not entirely correct. Although the HOLC areas were drawn consistent with natural boundaries in the movement network, the changes

between the historical and contemporary maps were not significant enough to conclude that the potential for through movement has increased over time. It is more accurate to say that natural boundaries first shaped the demarcations between HOLC areas, and then these areas were fixed in place by other social and economic factors like 'white flight', neighbourhood desirability, and the Bronx's own image of 'urban deterioration' during the 1960s and 70s (Gonzalez 2003, 1). The more significant changes occurred not between the historical and contemporary maps but rather between the radii of the various analyses. For example, in section 4.2 which looked at the HOLC areas related to the street configuration, percentage differences in the HOLC boundaries and the difference between choice routes and streets perpendicular to them were the most significant at global radii. These findings are consistent with the way Robert Moses saw the city 'as a unit', a 'physical tapestry of land masses, waterways, and structures' far from the lived experience of the neighbourhoods themselves (Ballon and Jackson 2007, 66). This also relates back to Hanson's (1989) distinction between order and structure: order is what is seen in plan based on organising principles, and structure is the understanding of the urban realm from the lived experience of neighbourhoods. This juxtaposition has shaped New York City and the surrounding region into the complex movement network it is today.

5.3 Cross Bronx-Expressway: Spatial Severance and Public Health

After the analysis of the Cross-Bronx Expressway's effect on the surrounding movement network, it was found that the hypothesis for the third research question was not entirely correct. It was originally predicted that the Expressway would show impacts on the movement network adjacent to the segments which were severed and that the impacts would be less severe as the radius increased. Although the streets that were severed by the Expressway did indeed show changes between the historical and contemporary maps, the percentage change analysis for choice did not vary significantly between the studied radii. And for the integration analysis, again the streets adjacent to the Expressway showed changes, but as mentioned previously, the NYCHA buildings father away from the Expressway also severed street segments which

had an effect on the whole study area. It was noted in the literature review that one of the fundamental principles of space syntax theory is the concept of 'natural movement' from B. Hillier (1993) which states that spatial configuration is the 'primary generator' of movement within a spatial network (31). Understanding New York City and the surrounding region as a series of interconnected islands that were all imbued with potential connectedness—in addition to the automobile and the development of the suburbs—helps to contextualise the point of view from which Robert Moses saw the city. Penn et al. (1998) point to a phenomenon of 'supply and demand [in] urban road space' where a higher amount of interconnected streets will increase the capacity for cars, resulting in the need for even more streets to meet demands (74). In New York City, this supply and demand cycle resulted in a complex network of larger streets, bridges, and expressways that were largely overseen by Robert Moses himself.

As mentioned previously, there are environmental costs with increased roadways including 'vehicle emissions, noise, and acute obnoxious releases from traffic accidents involving hazardous materials' (Jacobson, Hengartner, and Louis 2005). This research will conclude with a brief look at some of the environmental and public health consequences of larger roadways in cities. Kheirbek et al. (2016) have conducted a study which modelled the effects of air particulates from motor vehicles on public health within New York City. The research estimates that over 300 preventable deaths and almost 900 emergency department visits and hospitalisations annually are due to fine particulate matter exposure (ibid, 6). Juliana Maantay's (2007) study uses GIS modelling to analyse causes of asthma within the Bronx, citing 'pollution sources from vehicular traffic' among a list of other air pollutants responsible (40). And lastly, Kim et al. (2018) look at the cost effectiveness of capping freeways to be used as parks, and they specifically analyse the Cross-Bronx Expressway as a case study. Their research found that capping the Expressway would save both money and lives, and they argued that increased green space also increases community well-being and property values as a by-product (ibid, 382).

5.4 The Bronx and the American City

The story of the Bronx is most certainly a dynamic one, and this research has intended to understand a small aspect of it from a socio-spatial perspective. It is difficult to look at the urban history of the Bronx—and New York City in general—without considering the various top-down institutions which have shaped it. Demographically it became like the story of so many other American cities, as Rothstein notes a 'nationwide system of urban ghettos, surrounded by White suburbs' (2017, xii). This contradiction between the grid as the foundation of Major's (2018) 'egalitarian or democratic space' and the institutions that have shaped the American city into racially- and class-divided systems is still pervasive today. The boundaries that divide urban from suburban, Black from White, and rich from poor are so often spatial phenomena that continue to shape the core of American culture and society.

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