HOLC "REDLINING" MAPS:
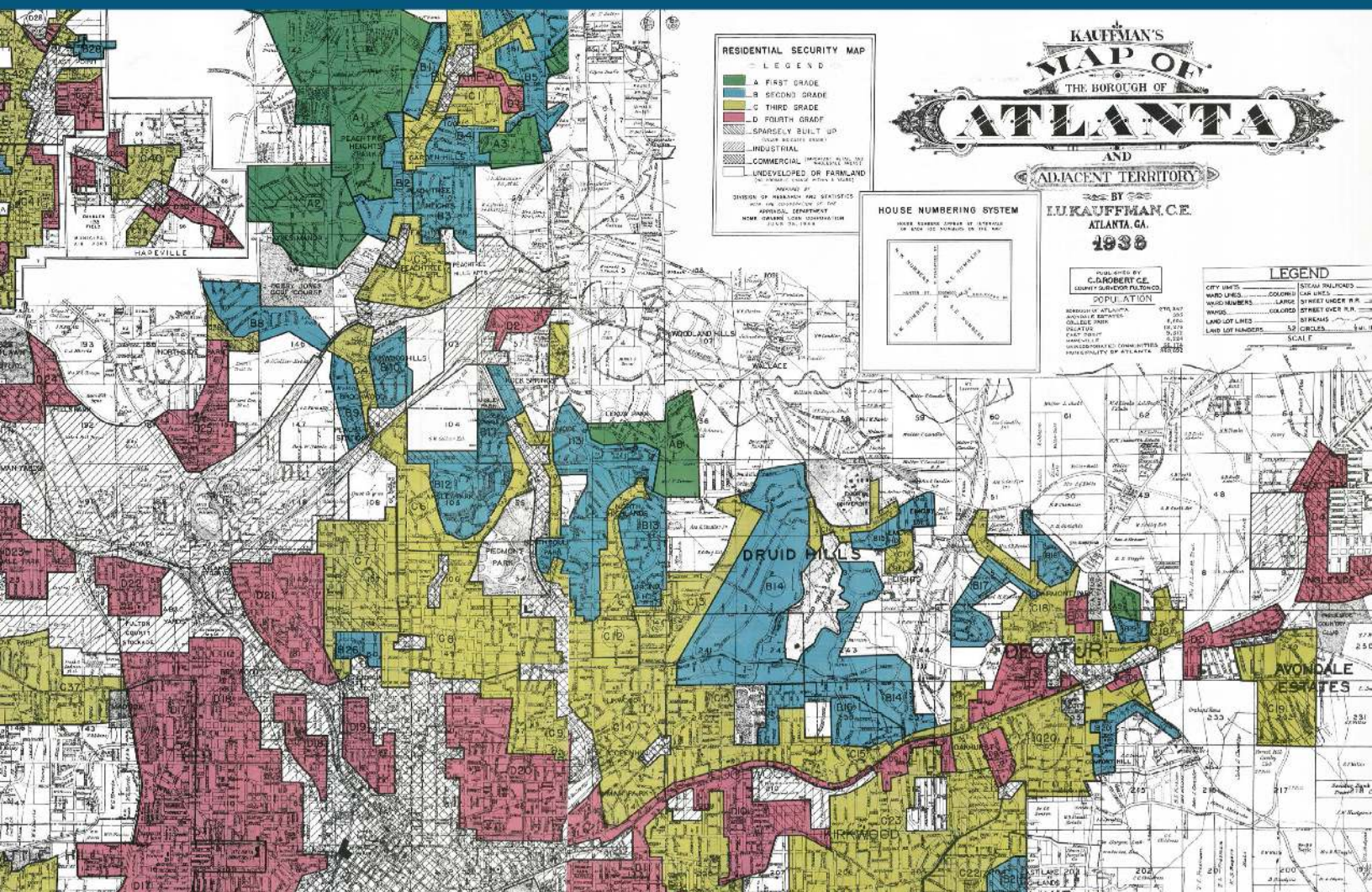
The persistent structure of segregation and economic inequality

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ABOUT NCRC

NCRC and its grassroots member organizations create opportunities for people to build wealth. We work with community leaders, policymakers and financial institutions to champion fairness in banking, housing and business development.

Our members include community reinvestment organizations, community development corporations, local and state government agencies, faith-based institutions, community organizing and civil rights groups, minority and women-owned business associations, and social service providers from across the nation.

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EXECUTIVE SUMMARY

Eighty years ago, a federal agency, the Home Owners' Loan Corporation (HOLC) created "Residential Security" maps of major American cities. These maps document how loan officers, appraisers, and real estate professionals evaluated mortgage lending risk during the era immediately before the surge of suburbanization in the 1950's. Neighborhoods considered high risk, or "Hazardous" were often "redlined" by lending institutions, denying them access to capital investment which could improve the housing and economic opportunity of residents. This study examines how neighborhoods were evaluated for lending risk by the HOLC, and compares their recent social and economic conditions with city-level measures of segregation and economic inequality. The study reveals:

The economic and racial segregation created by "redlining" persists in many cities

- Redlining buttressed the segregated structure of American cities. Most of the neighborhoods (74%) that the HOLC graded as high-risk, or "Hazardous" eight decades ago are low-to-moderate income (LMI) today. Additionally, most of the HOLC graded "Hazardous" areas (nearly 64%) are minority neighborhoods now.

Persistent economic inequality

- There is significantly greater economic inequality in cities where more of the HOLC graded high-risk or "Hazardous" areas are currently minority neighborhoods. To a lesser extent this is also true of cities where more of the HOLC low-risk, or "Desirable" areas have remained white. This could indicate that cities with less change in the racial and ethnic structure of their neighborhoods over the past 80 years have greater economic inequality today.

Persistent residential segregation

- Cities where more of the HOLC high-risk graded "Hazardous" neighborhoods are mostly minority are associated with "hypersegregation". Both black and Hispanic residents of hypersegregated cities are unevenly distributed and have lower levels of interaction with non-Hispanic whites. Minority residents also tend to be more clustered in neighborhoods of cities where there were more HOLC higher-risk, or "Hazardous" neighborhoods.

Gentrification is related to some lessening of segregation, but also with increased economic inequality

- Gentrification is associated with greater economic change in the HOLC highest-risk, "Hazardous" neighborhoods and higher levels of interaction between black and white residents, but also greater economic inequality in cities. Gentrification probably occurred in the HOLC "Hazardous" graded areas because of decades of depressed home values.

Regional differences in changes of HOLC "Hazardous," and LMI and majority-minority areas

*   Cities in the South showed the least change in the HOLC-evaluated "Hazardous" neighborhoods that today have lower incomes and higher populations of majority-minority residents. The Midwest closely followed the South in the persistence of low-to-moderate income (LMI) neighborhoods and HOLC "Hazardous" areas.

INTRODUCTION

Access to credit––home mortgage and small business loans––is an underpinning of economic inclusion and wealth-building in the U.S. Credit access, however, varies greatly depending on individual creditworthiness, and also on place-based factors like economic conditions of prosperity and growth which shape local credit markets. Another determinant of credit access is the risk associated with lending, which can be mitigated by the value of the collateral. Home mortgage lending credit access is subject to all of these factors, with the property collateralizing the loan. As a consequence, it has a neighborhood-level spatial structure, presenting a geography which can be examined in maps of cities across the country. Redlining––the practice of denying borrowers access to credit based on the location of properties in minority or economically disadvantaged neighborhoods––was widely practiced across the U.S., even in places not commonly associated with "Jim Crow" segregation laws (Rothstein 2017). While overt redlining is illegal today, having been prohibited under the *Fair Housing Act of 1968,* its enduring effect is still evident in the structure of U.S. cities. Part of the evidence of this enduring structure can be seen in the Home Owners' Loan Corporation (HOLC) maps created 80 years ago, and the neighborhood economic and racial/ethnic composition today. The maps were created by the HOLC as part of its City Survey Program in the late 1930s. The HOLC deployed examiners across the country to classify neighborhoods by their perceived level of lending risk.

HOLC examiners consulted with local bank loan officers, city officials, appraisers, and realtors to create "Residential Security" maps of cities. More than 150 of these maps still exist. The examiners systematically graded neighborhoods based on criteria related to the age and condition of housing, transportation access, closeness to amenities such as parks or disamenities like polluting industries, the economic class and employment status of residents, and their ethnic and racial composition. Neighborhoods were color-coded on maps: green for the "Best," blue for "Still Desirable," yellow for "Definitely Declining," and red for "Hazardous."

NCRC has taken these maps and compared the grading from 80 years ago with more current economic and demographic status of neighborhoods as low-to-moderate income (LMI), middle-to-upper income (MUI), or majority-minority. To a startling degree, the results reveal a

persistent pattern of both economic and racial residential exclusion. They provide evidence that the segregated and exclusionary structures of the past still exist in many U.S. cities.
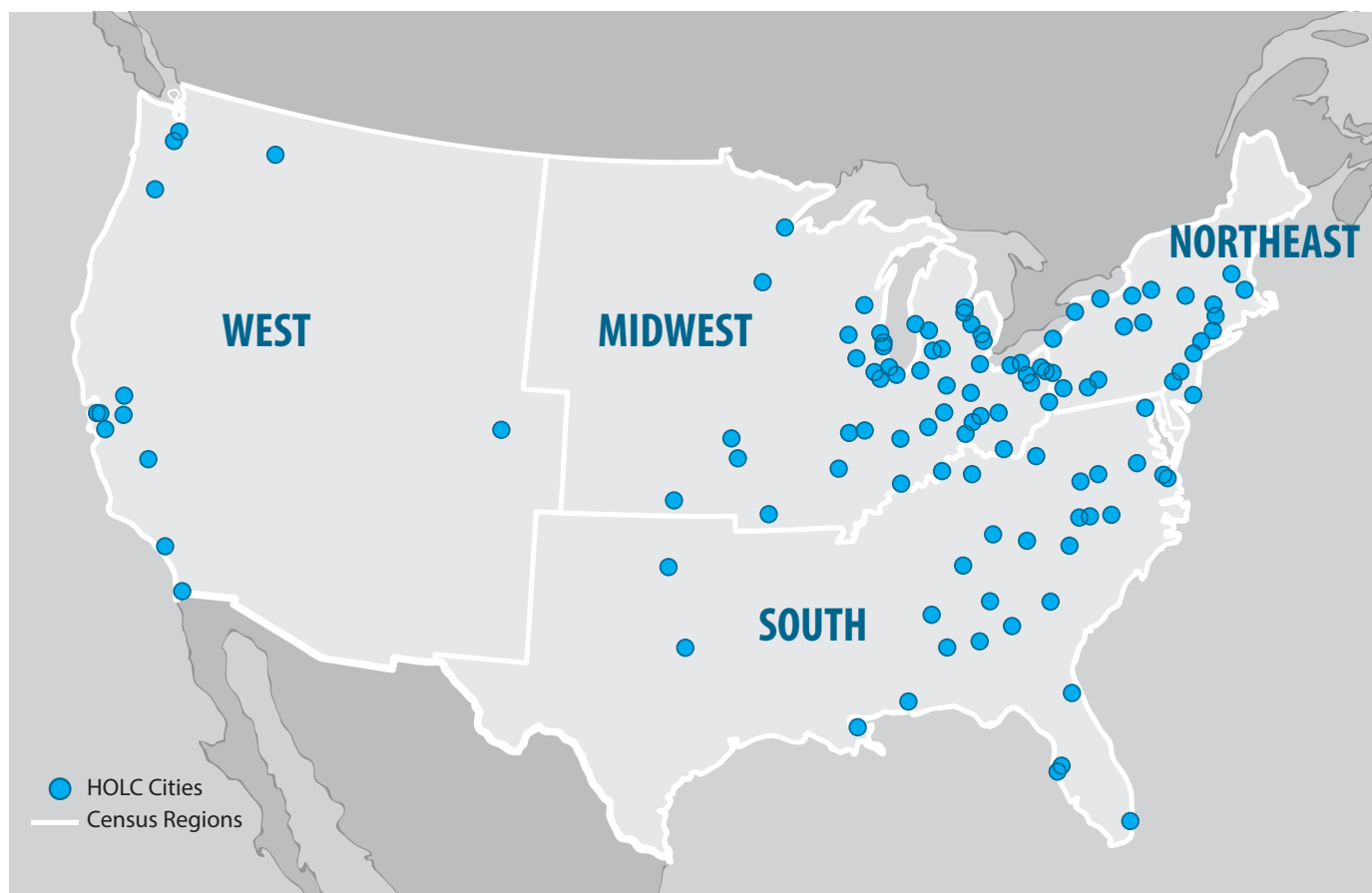

Fig. 1 All cities in the study with regional divisions.

In 1933, the HOLC was established to assist homeowners who were in default on their mortgages and in foreclosure. The HOLC was one of many "New Deal" programs––policies intended to relieve the worst effects of the Great Depression––leading the way in establishing the modern government-backed mortgage system. In the case of the HOLC, stabilization of the nation's mortgage lending system was the primary goal. It accomplished this task by purchasing mortgages that were in default, providing better terms for financially struggling families. For example, the HOLC and the Federal Housing Administration (FHA) introduced innovative loan programs, making fully amortized loans available over a 25-year period (Crossney and Bartelt 2005). This replaced the previous private and locally based system in which mortgages were usually made only for 5 to 10 years, at the end of which a "balloon" payment, covering the entirety of the principal, was due. Some scholars have argued that the maps and codification of appraisal practices introduced by the HOLC bolstered "redlining" as a pattern in government

mortgage lending (Jackson 1987; Massey and Denton 1993). Others have argued that the maps were confidential documents and an analysis of individual HOLC loans, most of which were made by 1936, before the "residential security maps" were completed, indicates that the agency provided mortgages to both white and minority borrowers (Hillier 2003a, 2003b; Crossney and Bartelt 2005). From this evidence it appears that the residential security maps were not used by the HOLC to qualify mortgage refinancing; however, it is unclear to what degree the maps may have been used later, by FHA appraisers. Hillier (2003b) found that when conventional loans were made in HOLC red-coded "Hazardous" areas, they had higher interest rates for borrowers, and also found discriminatory practices by the HOLC in allowing brokers to follow local segregation standards in the resale of properties acquired by foreclosure. Greer's 2014 analysis extends beyond the HOLC maps themselves to encompass later FHA mortgage risk maps of Chicago, finding that those maps directly impacted lending decisions, barring loans over larger sectors of the city. While the ultimate use of the HOLC residential security maps is a subject of debate, it is clear that the HOLC maps compiled the common understanding of local-level lending decision makers of the risk in the neighborhoods of their cities. Consequently, the HOLC maps document which areas were considered lower risk, and therefore preferred for loans, and higher-risk areas where lending was discouraged. The maps document the neighborhood structure of cities and indicate areas which may have been subject to "redlining" by banks when making lending decisions. Since the HOLC maps document the contemporary expert judgement of neighborhood lending risk, they provide an archive of lending risk perception immediately prior to World War II––background material which can help us understand the extensive reconfiguration of the U.S. urban system with the explosion in suburbanization of the post-WWII period.

This study utilizes neighborhood-level grading from the HOLC maps to assess both the economic status and proportion of minorities living in those areas today. Digitized images of the HOLC Residential Security maps for 115 cities were compared with the presence of LMI and MUI income census tracts currently in those areas using 2010 Decennial Census, and 2016 Federal Financial Institutions Examination Council (FFIEC) Census-derived data. This data was compared then statistically analyzed at the national, regional, and city levels. The questions of this analysis concern the persistence of inequality in cities where the structure documented by the HOLC maps has changed the least; regional differences between cities; and the relationship of neighborhood change and recent gentrification. Specifically, the questions are:

1) What proportion of the area on the HOLC maps classified least favorably as "Hazardous" ("D" or colored red) is presently occupied by LMI and minority-majority communities for each city? What proportion classified with the most favorable grade of "Best" ("A" or colored green) is currently non-Hispanic white and MUI?

2) Are there regional differences in how the city-level changes took place?

3) Do cities with greater persistence of an inequitable structure (more HOLC "Hazardous" or "D" graded areas that are minority-majority and/or LMI) correlate with current indicators of economic inequality and segregation?

4) Is there an association between higher levels of gentrification and the change of HOLC "Hazardous" or "D"-graded areas into higher income MUI and majority non-Hispanic white areas?

These questions are approached through the spatial analysis of the HOLC map archive, and the degree to which the old grading corresponds with current neighborhood economic and racial/ethnic status. This is then compared with overall city-level indicators of segregation and economic inequality.

METHODS

Digitized images of the original HOLC maps were used to compute the percentage of area in the original maps of each city that were graded A, B, C, or D (corresponding to green = "Best"; blue = "Still Desirable"; yellow = "Declining"; and red = "Hazardous" designations, respectively).[1] The digitized HOLC classification areas were then compared to the current economic status and racial/ethnic composition of census tracts within those areas. For economic status, the median family income (low-to-moderate, or middle-to-upper) based on FFIEC 2016 criteria was used, adjusted by the median family income of the MSA each city was part of. The racial/ethnic composition was quantified by taking the non-Hispanic white population of each census tract into consideration and classifying it as either majority-white, or majority-minority. Percentages of areas for the HOLC grade were then calculated for each city. Taking Atlanta as an example, 100% of the areas graded "A" or "Best" in 1938 were in majority non-Hispanic white census tracts in the 2010 Decennial Census, and 100% of those areas were also classified as MUI, while over 81% of the areas classified "D" or "Hazardous" are majority-minority, and over 71% are in LMI census tracts (Figure 2). We condensed large metropolitan areas with numerous individual HOLC maps to a total of 115 digitized city maps. All of the maps were classified this way so that they could be compared for the changes in their neighborhood structure over time.

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1   All digitized HOLC map files were taken from the University of Richmond "Mapping Inequality" project, available here: https://dsl.richmond.edu/panorama/redlining/
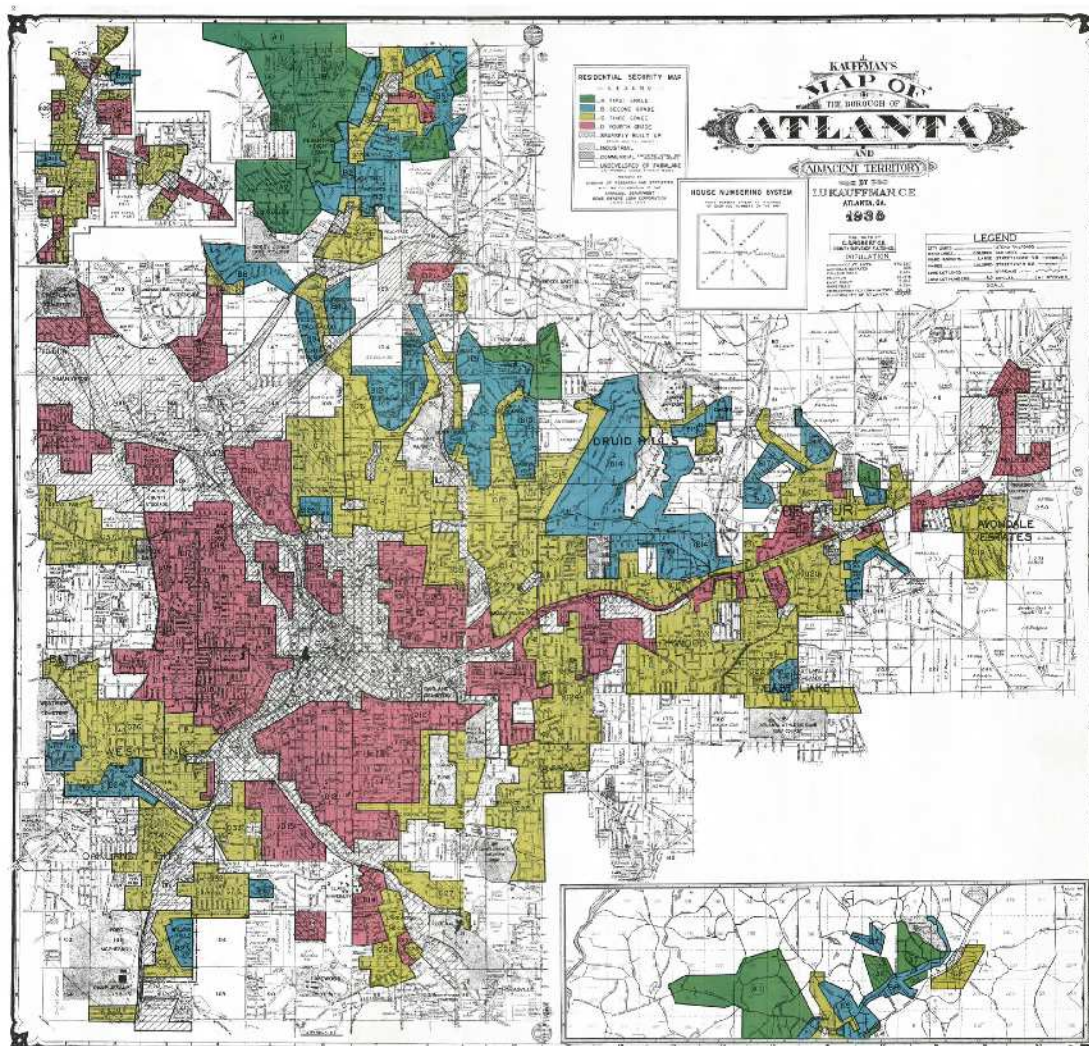
Fig. 2. Example of the original 1938 HOLC "Residential Security" map of Atlanta with color-coded gradation of neighborhoods by risk level. (Source: Mapping Inequality Project, University of Richmond)

DESCRIPTIVE ANALYSIS

The first question posed in this study is: *What proportion of the area on the HOLC maps classified least favorably as "Hazardous" ("D" or red) is presently occupied by LMI and minority-majority communities for each city? What proportion classified with the most favorable grade of "Best" ("A" or green) is currently non-Hispanic white and MUI?* In order to address this, we analyzed areas that were classified 80 years ago by HOLC examiners as "Best" and "Hazardous," revealing the startling persistence of an unequal and segregated urban structure. Nationally, over 91% of the areas classified as the "Best" are MUI today, while 74% of the "Hazardous" areas are LMI (Figure 3). Over 72% of "Desirable" neighborhoods are MUI, while neighborhoods classified as "Declining" were split between LMI and MUI. Additionally, over 85% of the HOLC "Best" and 71% of the "Desirable" neighborhoods are currently non-Hispanic white areas (Figure 4). On the other hand, 63% of the "Hazardous" areas are currently majority-minority.

National HOLC Grades and Income

	A Best	B Desirable	C Declining	D Hazardous
■ LMI	8.61%	27.27%	53.94%	74.40%
■ MUI	91.39%	72.73%	46.06%	25.60%
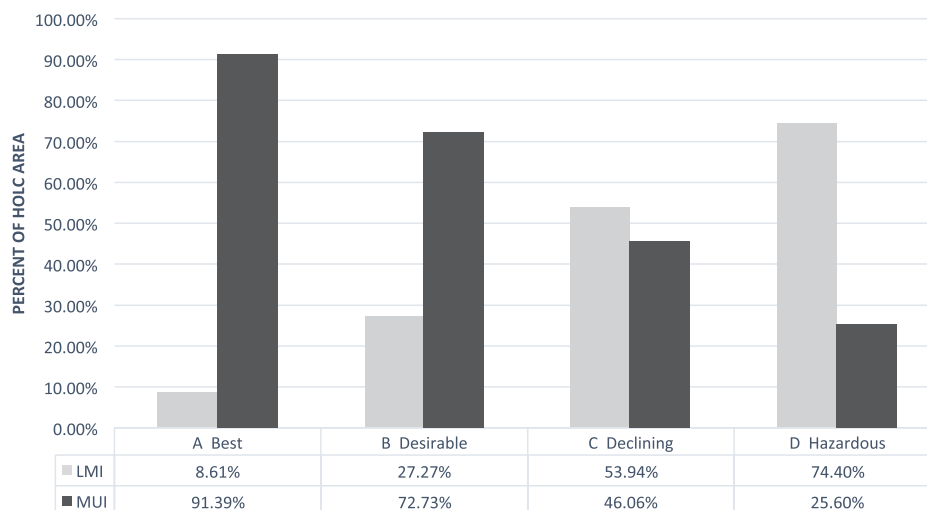
Fig. 3. Percentage of areas with HOLC grades that are currently low-to-moderate or middle-to-upper income nationally. (Source: Original 1935-1940 HOLC maps and 2016 FFIEC Census- and ACS-derived data on income)

National HOLC Grades and Race

	A Best	B Desirable	C Declining	D Hazardous
■ White	85.82%	71.57%	54.91%	35.16%
■ Minority	14.18%	28.43%	45.09%	63.84%

Fig. 4. Percentage of areas with HOLC grades that are currently majority non-Hispanic white, or majority-minority nationally. (Source: Original 1935-1940 HOLC maps and 2016 FFIEC Census data)

The data was analyzed in order to answer the second question: *Are there regional differences in how the city-level changes took place?* When the data is analyzed regionally at the city level, differences in patterns are evident in areas of the country. Cities were divided among the four U.S. Census regions of Northeast; Midwest; South; and West. All regions had very high consistency of the HOLC "Best" grade and the current percentage of middle-to-upper income

areas, with the West being highest at 94% (Table 3). There was less regional consistency for the HOLC "Hazardous" ratings and low-to-moderate income areas, with the Midwest and South having the highest percentages of LMI of over 80%, and the West the lowest at 68%. High percentages of the HOLC-graded "Best" and "Desirable" areas are majority non-Hispanic white, with the highest percentage of "Best" being in the West. Consistency of HOLC "Hazardous" areas and majority-minority was weaker; however, the South still had the greatest percentage of areas that were consistently minority, at 72%.

Regional HOLC Grades and Income

Fig. 5. Regional HOLC grades and current income. (Source: Original 1935-1940 HOLC maps and 2016 FFIEC Census- and ACS-derived data on income)

Regional HOLC Grades and Race

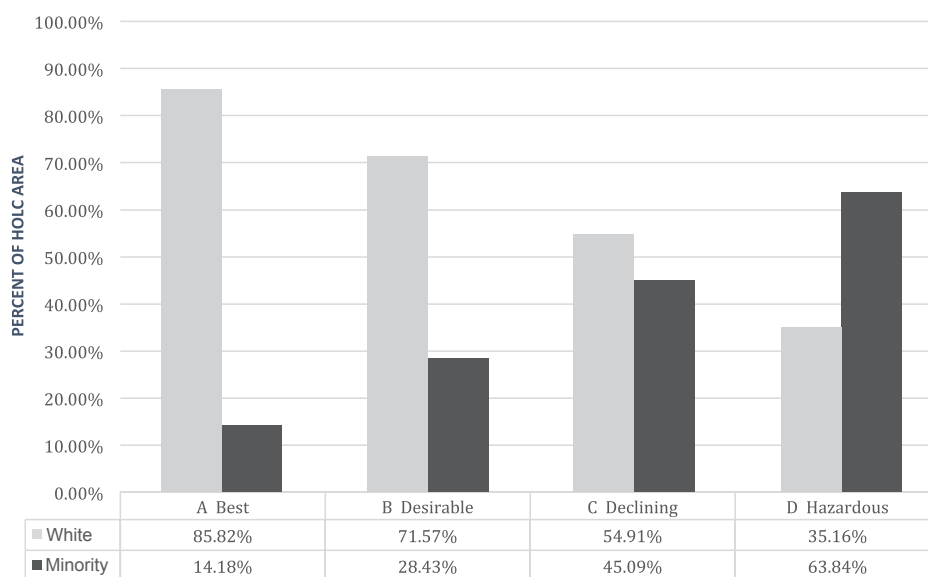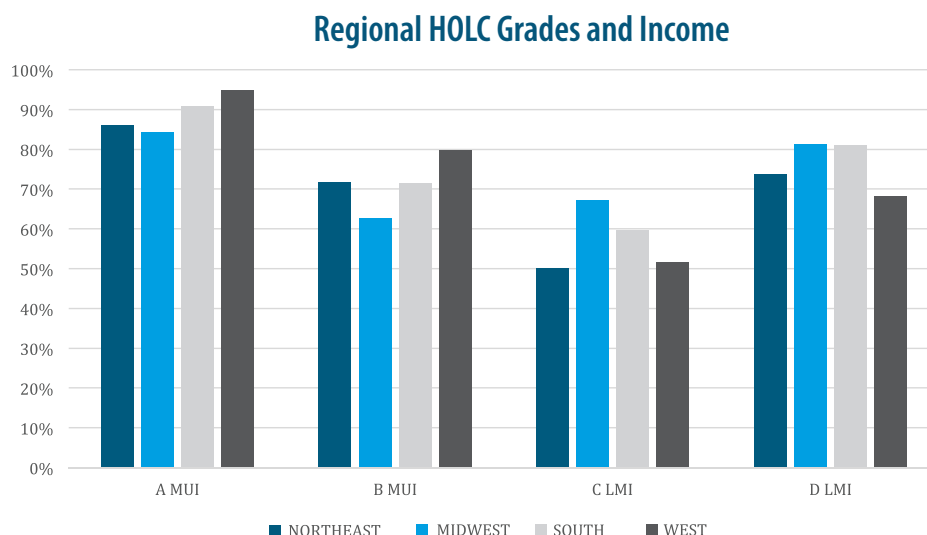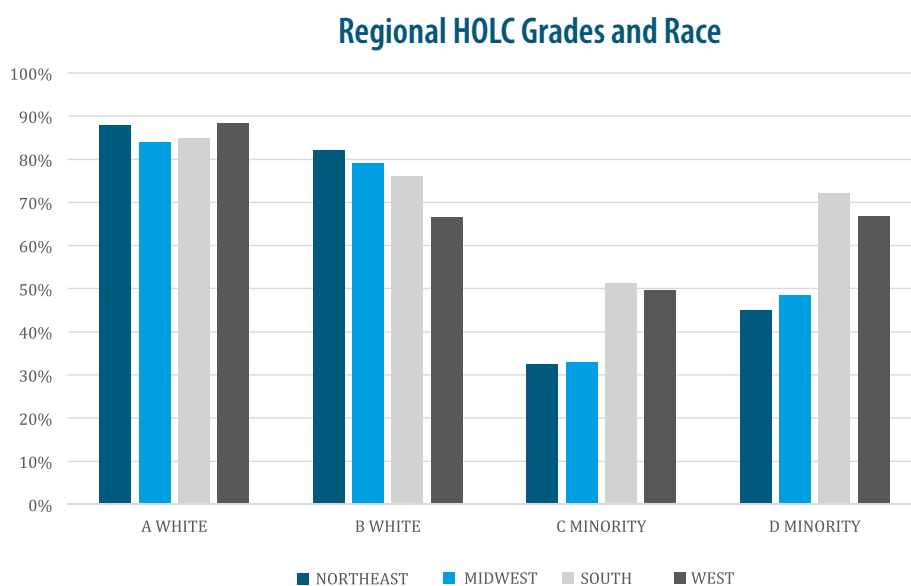Fig. 6. Regional HOLC grades current majority non-Hispanic white, or majority-minority status. (Source: Original 1935-1940 HOLC maps and 2016 FFIEC Census-and ACS-derived data on income)

Overall, cities in the South and Midwest have the highest percentages of "Hazardous" areas that are low and moderate income, indicating persistent inequity in these areas over decades. In addition to the persistence of economic disadvantage, the Southern cities have more areas that were evaluated "Hazardous" and are now majority-minority. This suggests that the urban structure in the most segregated and economically disadvantaged Southern cities has undergone less change than other regions of the country. Cities which have changed the least over the past eight decades seem to have higher levels of segregation and inequality; however, cities with greater gentrification also seem to have increased economic inequality, as will be seen in the analysis of a subset of cities.

STATISTICAL ANALYSIS:

Segregation, Inequality and "Hazardous" Areas

The third question of this study is: *Do cities with greater persistence of an inequitable structure (more "redlined" areas that are minority-majority and/or LMI) correlate with current indicators of economic inequality and segregation?* In order to assess the relationship between persistent structures of the HOLC-evaluated areas of cities, we conducted a statistical analysis of the HOLC change data and common measures of economic inequality and segregation. Residential segregation is a multidimensional phenomenon, and researchers recommend that the evenness of the residential distribution of minority and majority groups be assessed, along with the groups' level of interaction, and the concentration and clustering of the minority group (Massey and Denton 1988, 1989). We chose four well-known measures to examine this: index of dissimilarity, interaction index, concentration index, and spatial proximity index. All of these were produced using population data from the 2010 Decennial Census specifically for the areas of the cities surveyed in the original HOLC maps. Additionally, the Gini coefficient of economic inequality calculated by the U.S. Census for the entire city area was used. First, a series of bivariate correlations were calculated; then scatterplots with the line of fit; and finally, ordinary least squares regression models were run.

Bivariate Correlations

Bivariate correlations between each individual measure of HOLC grade and its current income and racial/ethnic composition and indicators of segregation and economic equality at the city level were compared. This portion of the analysis focuses on the level of change in a city's HOLC graded neighborhoods and their current economic status and demographic composition. This is then contrasted with the city-wide level of economic inequality and segregation to answer the question: *Do cities with greater persistence of an inequitable structure (more "redlined" areas that are minority-majority and/or LMI) correlate with current indicators of economic inequality and segregation?* First, cities with a higher percentage of HOLC-graded

"Best" and "Desirable" neighborhoods that are currently MUI are significantly correlated with greater levels of economic inequality as measured by the Gini coefficient. Additionally, cities with higher percentages of areas graded by the HOLC as "Declining" and "Hazardous" that are now majority-minority have greater economic inequality. Only cities with a higher percentage of "B" or "Desirable" areas with more non-Hispanic white residents are associated with increased economic equality. This indicates a pattern in which cities with MUI and majority-minority neighborhood permanency are associated with greater economic inequality.

Results of the bivariate correlations having to do with demographic change in HOLC-graded neighborhoods and measures of segregation are more complex to interpret (Table 1). Cities with higher percentages of HOLC "Declining" and "Hazardous" neighborhoods that are currently majority-minority have greater unevenness in the distribution of minority and white residents and lower levels of interaction between races/ethnicities, along with greater minority clustering. This indicates that cities in which HOLC poorly evaluated neighborhoods have changed the least are also more highly segregated in multiple dimensions.

Interestingly, the pattern identified by the bivariate correlations above is inverted for cities where there are higher percentages of "Desirable" or "B"-graded neighborhoods that are also non-Hispanic white. In these cases, the stability of these associations correlates with higher levels of evenness, greater interaction, and lower clustering of both blacks and Hispanics. For the "Best" or "A"-graded areas, greater interaction is also correlated with higher percentages of non-Hispanic white neighborhoods; however, there is also an association with increased minority concentration. The differences in these two findings suggest that perhaps higher percentages of majority-minority neighborhoods than non-Hispanic white neighborhoods are associated with higher segregation levels.

HOLC	BLACK EVENNESS	BLACK INTERACTION	BLACK CONCENTRATION	BLACK CLUSTERING	HISPANIC EVENNESS	HISPANIC INTERACTION	HISPANIC CONCENTRATION	HISPANIC CLUSTERING	GINI
A-MUI	.089	.050	.203**	.093	.079	.073	.198**	.024	.171*
B-MUI	-.025	.195**	.071	-.031	.016	.135	.089	.069	.266***
C-LMI	.084	-.268***	-.177*	.039	.023	-.178*	-.161	-.107	-.120
D-LMI	.040	-.308***	-.105	.023	.087	-.264***	-.010	-.041	-.091
A-White	0.008	0.155*	0.176*	0.028	0.03	0.174*	0.271**	-0.03	0.095
B-White	-0.415***	0.558***	-0.027	-0.438***	-0.373***	0.489***	0.028	-0.333***	-0.214**
C-Minority	.476***	-.721***	-.024	.450***	.499***	-.692***	-.005	.349***	.319***
D-Minority	.461***	-.790***	-.088	.422***	.493***	-.745***	.009	.372***	.324***

N=115   *** p<.01; ** p<.05; * p<.10

Table 1 Bivariate correlations of HOLC and data of current status with indices of segregation and economic inequality
(Source: Author's calculations of HOLC areas and Census 2010 and ACS data)

GENTRIFICATION

The final question concerns gentrification and its relationship with the changes in HOLC areas, economic inequality, and segregation: *Is there an association between higher levels of gentrification and the change of HOLC "Hazardous" or "D"-graded areas into higher income MUI and majority non-Hispanic white areas?* NCRC analyzed a subset of 30 cities of the original HOLC set for which data on the percentage of census tracts which gentrified between 2000 and 2010 was available. The methodology for qualifying a census tract as gentrified broadly follows criteria outlined in Freeman's paper (2005) and followed utilizing increased home value and educational attainment as indicators. Gentrification is defined as tracts within a city which had over 500 residents and were in the bottom 40th percentile for both household income and median home value at the beginning of the decade for the area, that saw an increase in both educational attainment and median home value, moving the tracts to the top third percentile for the decade.[2] The top and bottom five cities are presented in Table 2.

	CITY	TRACTS GENTRIFIED %
Top 5 cities in percent gentrified	Portland, OR	58.10%
	Minneapolis, MN	50.60%
	Seattle, WA	50.00%
	Atlanta, GA	46.20%
	Denver, CO	42.10%
Bottom 5 cities in percent gentrified	Louisville, KY	10.60%
	Dallas, TX	10.20%
	San Jose, CA	10.00%
	Cleveland, OH	6.70%
	Detroit, MI	2.80%

Table 2 Percentage of tracts in cities which were qualified for gentrification that gentrified 2000-2010. Top and bottom five listed. (Source www.governing.com/gov-data/)

To get a better spatial understanding of the HOLC-graded areas and gentrification, the most-and least-gentrified cities, Portland, Oregon and Detroit, Michigan, were mapped. The gentrification look-back period was extended in this mapping to encompass the periods from 1990-2000 and 2000-2010. In Portland's case there has been intense gentrification, with 58% of eligible tracts having been gentrified since 1990. The areas of the city west of the Willamette River were already MUI prior to 1990, so the extensive gentrification dynamic is evident only in the east. Only small areas with the HOLC "C" and "D" grade are not overlapped by gentrified tracts there (Figure 7).

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2   Full methodology is available here: http://www.governing.com/gov-data/gentrification-report-methodology.html
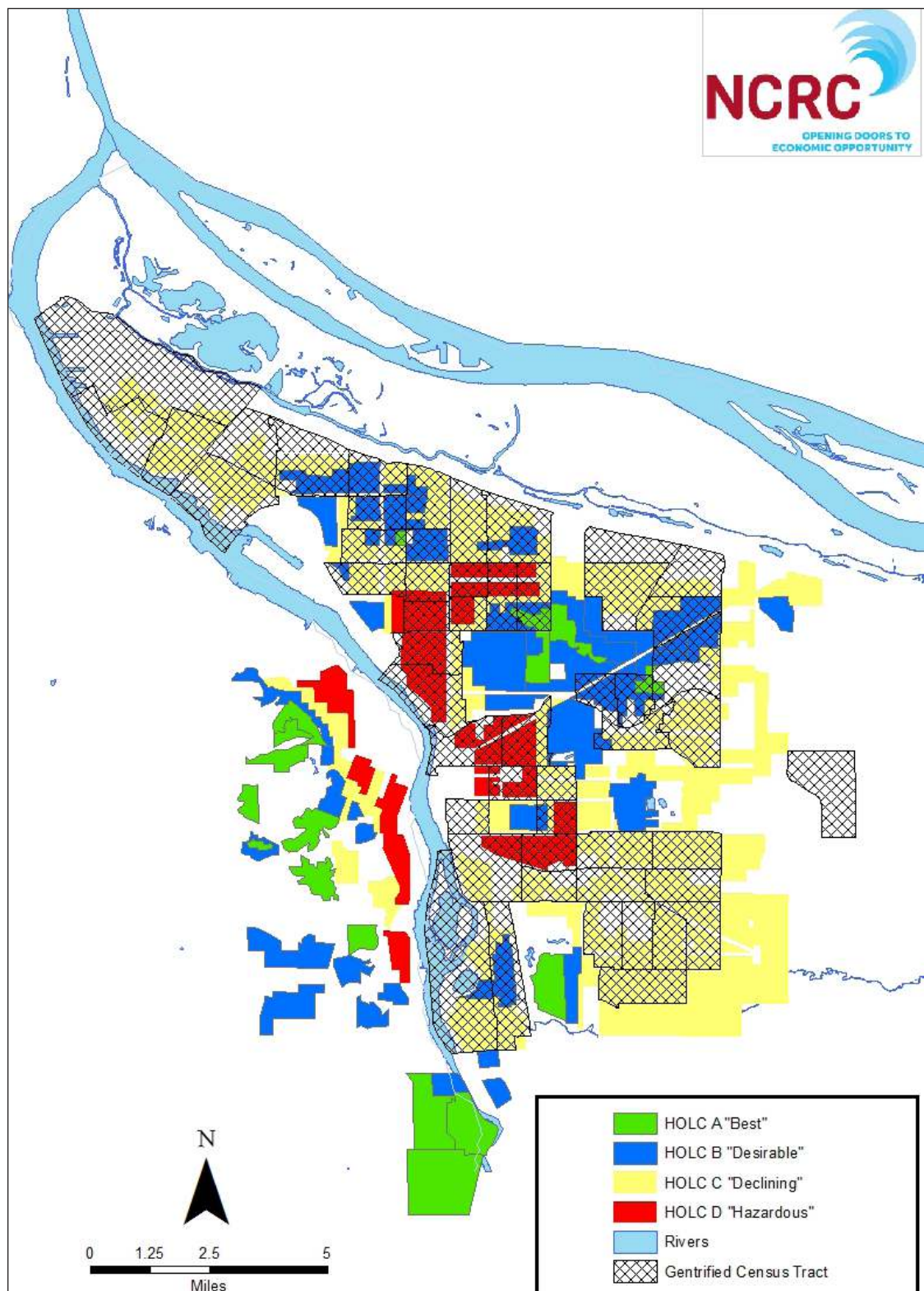
Fig. 7. Portland, OR with original HOLC grading and areas that gentrified between 1990 and 2010. Tracts west of the Willamette River were middle-to-upper income as of 1990. Portland was the most-gentrified city in the study, with over 58% of tracts eligible to gentrify having done so. (Source: HOLC map digitization by University of Richmond; gentrification data by Governing.com)

The map of Detroit contrasts starkly with this: the city saw less than 3% of eligible tracts gentrify over the 2000-2010 period. While a few areas around the downtown core underwent gentrification, the larger city was nearly untouched, especially in the western sections.
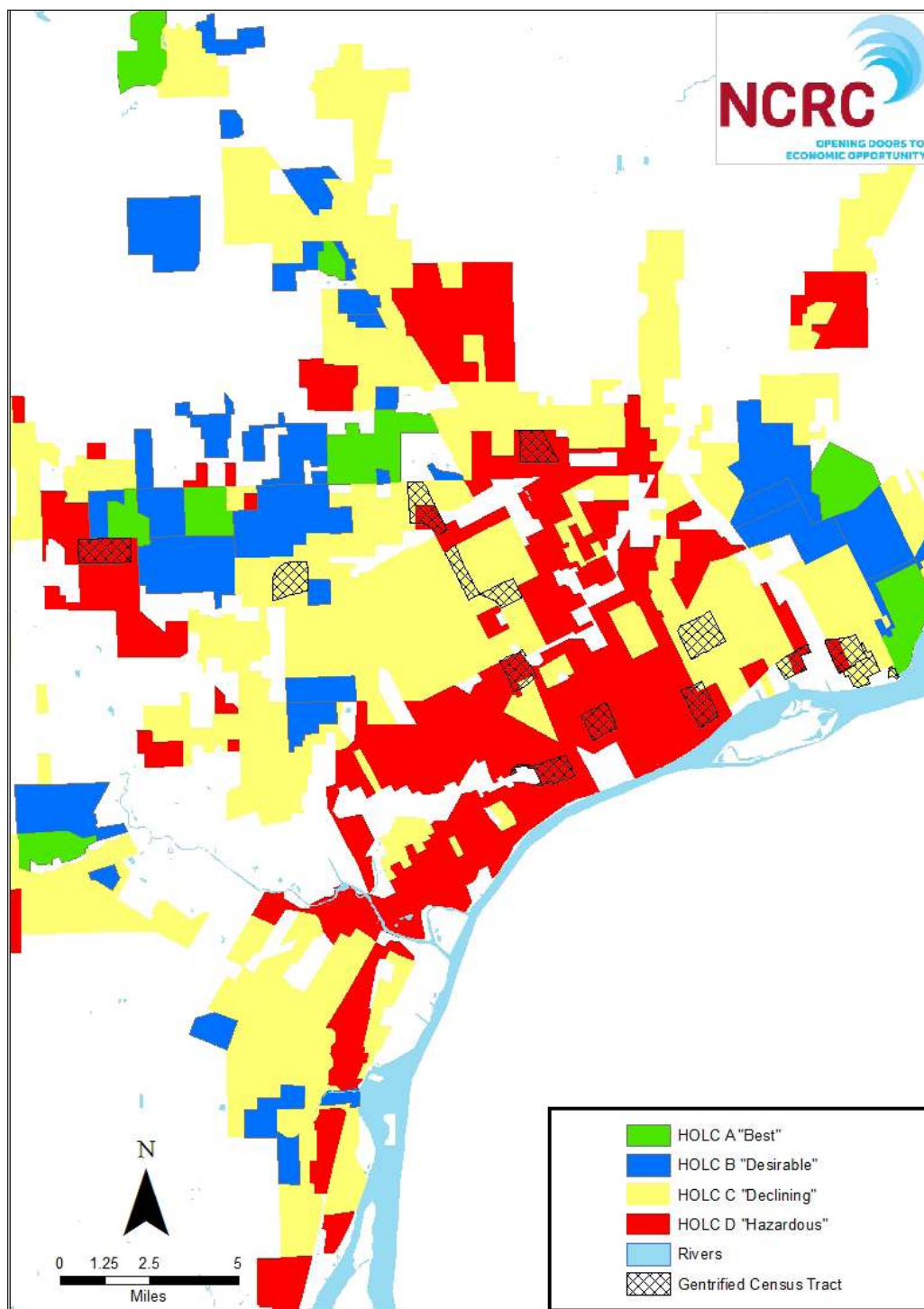

Fig. 8. Detroit, MI with original HOLC grading and areas that gentrified between 1990 and 2010. Detroit was the least-gentrified city in the study, with a little less than 3% of tracts eligible for gentrification having done so during the period. (Source: HOLC map digitization by University of Richmond; gentrification data by Governing.com)

To see which variables might be relevant in building a model of gentrification for our city samples, we used the percentage of tracts gentrified between 2000-2010 as a dependent variable in a stepwise ordinary least squares regression. We found that the number of HOLC "D"-graded areas that had become MUI, increased levels of black interaction, and greater economic inequality were all significant in our model construction. The overall model has a high adjusted R-square of .584 and is significant at the *p<.001* level (Table 3). This model indicates that cities with higher levels of gentrification, measured as tracts which gentrified between 2000 and 2010, were significantly associated with higher numbers of HOLC "Hazardous" areas which had become MUI, a key dynamic of gentrification. It is also significant that cities with higher black interaction, an indication of lower segregation, had greater gentrification, although no other segregation indices were significant. Finally, the Gini coefficient indicating economic inequality was significant, which may be interpreted as indicating greater gentrification and greater economic inequality are associated with each other.

VARIABLE	COEFFICIENT	STANDARD ERROR	T	SIGNIFICANCE
Constant	-.622	.301	-2.064	.049
D-MUI	.320	.108	2.962	.006
Black Interaction xPy	.585	.154	.538	.001
Gini Coefficient	1.230	.585	.281	.045
Adjusted R Square	.584			.000

N=30

Table 3 Regression model with the percentage of tracts gentrifying between 2000 and 2010 as the dependent variable, with indicators of segregation, economic inequality, and HOLC grade as independent variables.

CONCLUSION

The introduction of new modes of analysis such as spatial analysis to the HOLC maps has shifted understanding of how they were used in the mortgage loan underwriting process. Instead of being seen as formative documents establishing government complicity in redlining practices, the maps are part of a broad pattern of discriminatory practices in neighborhood lending risk assessment. This study used the maps as documents of the contemporary understanding of neighborhood-level mortgage lending risk across cities and regions of the U.S. We used the digitized maps to perform a comprehensive spatial analysis that quantifies the association between HOLC map classifications from the 1930s and the current economic and demographic status of neighborhoods at the city level. Descriptive analysis indicated a high degree of correspondence between HOLC high-risk grading and both economic disadvantage and majority-minority presence in neighborhoods to show a persistent pattern of economic inequality and segregation. A regional analysis showed that the South and West had the highest correspondence for HOLC high-risk grades and majority-minority neighborhood presence, while the South and Midwest had the most persistent economic inequality. A statistical analysis of all cities in the study confirmed that these associations were significant, finding that there is indeed a persistence of neighborhood conditions documented 80 years ago and increased segregation and economic inequality in cities. This shows a pervasive, enduring structure of economic disadvantage in urban areas of the U.S. Further analysis to examine the effects of gentrification, here defined as increasing median house values, increasing incomes, and increased educational attainment, showed an association with decreasing segregation measured by increased black and Hispanic interaction with whites; however, there are increased levels of economic inequality at the city levels.

This research is limited in that it does not address the relationship of redlining practices in establishing racial and ethnic segregation. Residential racial and ethnic segregation is rooted in widespread racial and ethnic prejudice of whites. The absence of legal protections for minorities allowed for the construction of a complex system of segregation, including restrictive covenants, local policies, and informal practices among lenders, the real estate profession, and developers. The HOLC maps document how these prejudices were reflected in the evaluation of lending risk across the neighborhood landscape. Later, underwriting practices institutionalized by the FHA, acted to further cement residential segregation in the urban structure of the United States. In future work we will assess these factors and develop policy and programmatic recommendations to address this deep structure of economic and racial segregation.

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APPENDIX

Grades/Income	LMI	MUI
A Best	8.61%	91.39%
B Desirable	27.27%	72.73%
C Declining	53.94%	46.06%
D Hazardous	74.40%	25.60%

Table A1 Percentage of areas with HOLC grades that are currently low–to-moderate or middle-to-upper income nationally. (Source: Original 1935-1940 HOLC maps and 2016 FFIEC Census- and ACS-derived data on income)

Grades/Minority	White	Minority
A Best	85.82%	14.18%
B Desirable	71.57%	28.43%
C Declining	54.91%	45.09%
D Hazardous	35.16%	63.84%

Table A2 Percentage of areas with HOLC grades that are currently majority non-Hispanic white, or majority-minority nationally. (Source: Original 1935-1940 HOLC maps and 2016 FFIEC Census- and ACS-derived data on income)

	Northeast		Midwest		South		West	
Grades/Income	LMI	MUI	LMI	MUI	LMI	MUI	LMI	MUI
Best	5.42%	86.58%	9.34%	84.28%	6.03%	90.64%	5.09%	94.91%
Desirable	28.19%	71.81%	37.36%	62.64%	28.58%	71.42%	20.28%	79.72%
Declining	51.39%	48.61%	67.24%	32.76%	59.20%	37.47%	51.77%	48.23%
Hazardous	74.75%	25.25%	81.22%	18.78%	80.41%	19.59%	68.26%	31.74%

Table A3 Regional HOLC grades and current economic status. (Source: Original 1935-1940 HOLC maps and 2016 FFIEC Census- and ACS-derived data on income)

Grades/Minority	Northeast		Midwest		South		West	
	White	Minority	White	Minority	White	Minority	White	Minority
Best	87.35%	8.65%	83.98%	9.64%	85.31%	11.36%	88.38%	11.62%
Desirable	81.35%	18.65%	79.01%	20.99%	76.45%	23.55%	66.68%	33.32%
Declining	66.21%	33.79%	67.12%	32.88%	45.87%	50.80%	50.27%	49.73%
Hazardous	53.81%	46.19%	51.54%	48.46%	27.93%	72.07%	33.26%	66.74%

Table A4 Regional HOLC grades currently majority non-Hispanic white, or majority-minority status. (Source: Original 1935-1940 HOLC maps and 2016 FFIEC Census- and ACS-derived data on income)

Regional Patterns – Scatterplots With Line-of-Fit By Region

1R^2 Linear = 0.016   2R^2 Linear = 0.021   3R^2 Linear = 0.146   4R^2 Linear = 0.219
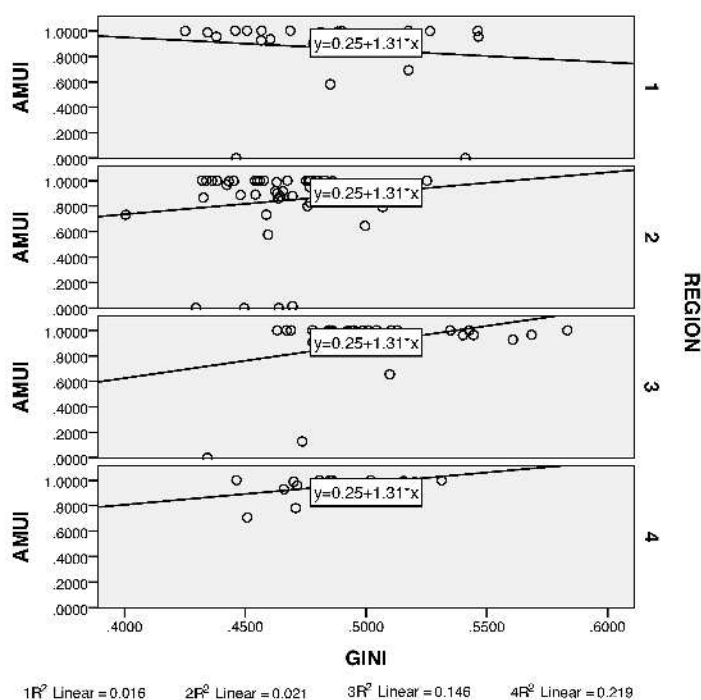
Fig. A1. Scatterplots for dependent variable percent change in HOLC "A" areas that are middle-to-upper income with line-of-fit for Gini index of economic inequality. Region 4 is West, r2 is highest at .219; region 3, South is next with r2 = .146; region 2 is Midwest with r2 = .021; and region 1, Northeast r2 = .016.

1R^2 Linear = 0.472   2R^2 Linear = 0.197   3R^2 Linear = 0.143   4R^2 Linear = 0.261

Fig. A2. Scatterplots for dependent variable percent change in HOLC "D" areas that are majority-minority with line-of-fit for black index of dissimilarity by region. Region 1 is Northeast where r2 is highest at .472; region 4, West is next with r2 = .261; region 2 is Midwest with r2 = .197; and region 3, South r2 = .143.

1R^2 Linear = 0.472   2R^2 Linear = 0.197   3R^2 Linear = 0.143   4R^2 Linear = 0.261

Fig. A3. Scatterplots for dependent variable percent change in HOLC "D" areas that are majority-minority with line-of-fit for Hispanic index of dissimilarity by region. Region 4 is West where r2 is highest at .522; region 1, Northeast is next with r2 = .463; region 2 is Midwest with r2 = .232; and region 3, South r2 = .182.

1R^2 Linear = 0.574   2R^2 Linear = 0.208   3R^2 Linear = 0.320   4R^2 Linear = 0.551
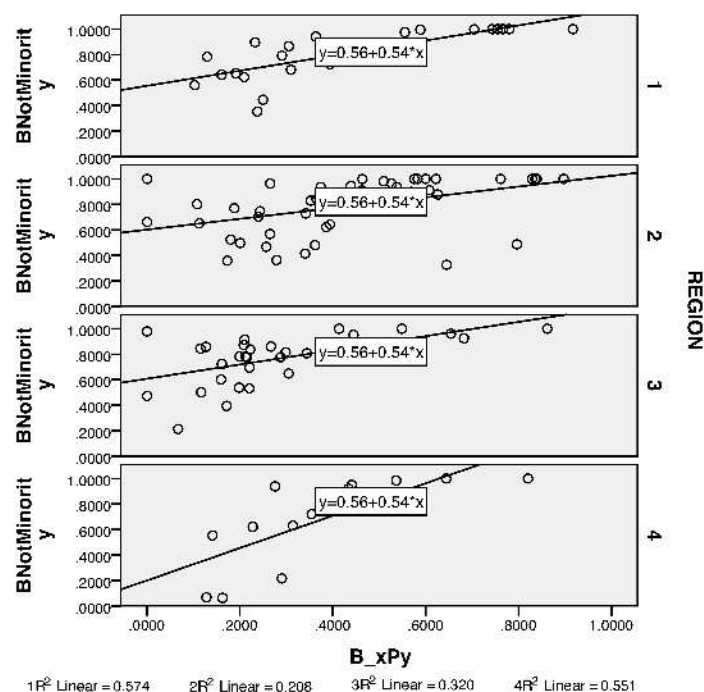
Fig. A4. Scatterplots for dependent variable percent change in HOLC "B" areas that are non-Hispanic white with line-of-fit for black interaction index by region. Region 1 is Northeast where r2 is highest at .574; region 4, West is next with r2 = .551; region 3 is South with r2 = .320; and region 2, Midwest r2 = .208.

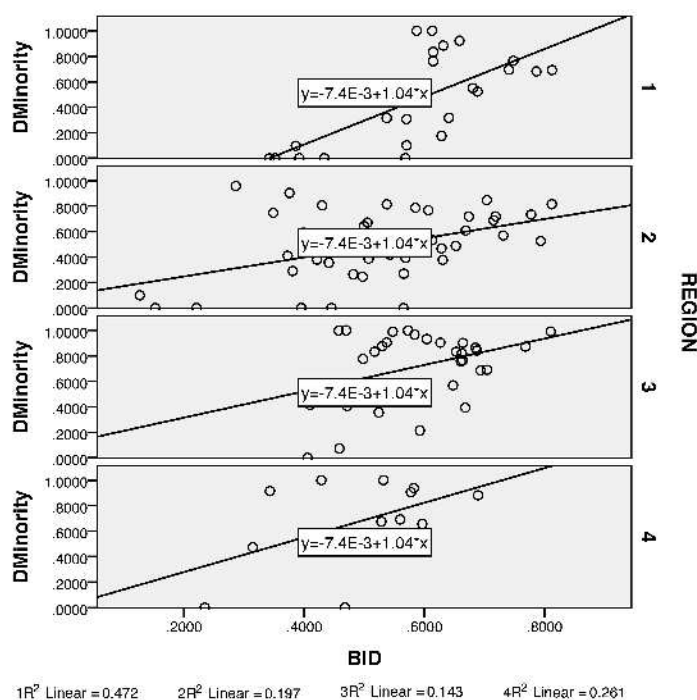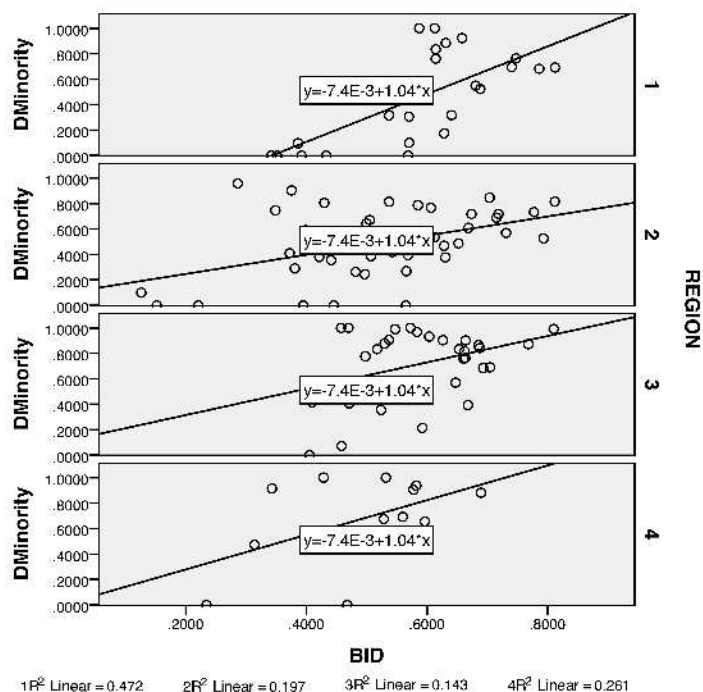1R^2 Linear = 0.672   2R^2 Linear = 0.439   3R^2 Linear = 0.694   4R^2 Linear = 0.876
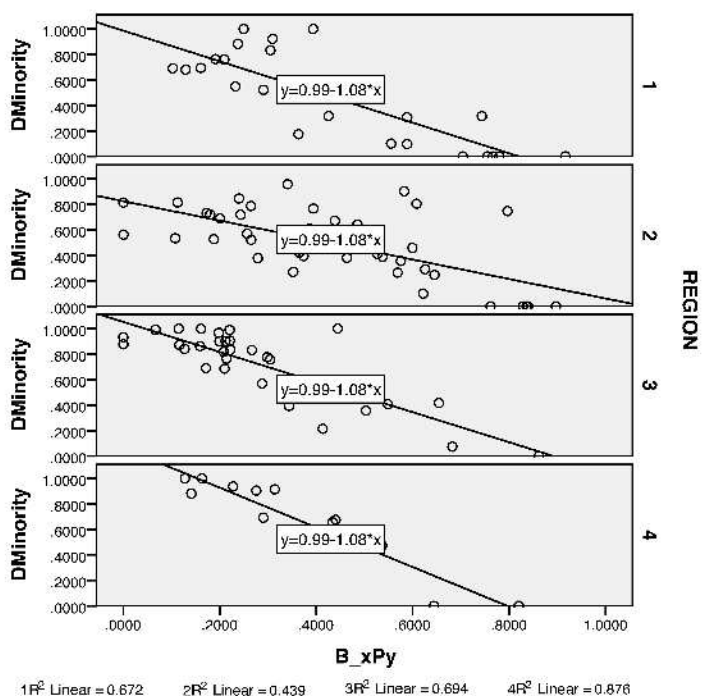
Fig. A5. Scatterplots for dependent variable percent change in HOLC "D" areas that are majority-minority with line-of-fit for black interaction index by region. Region 4 is West where r2 is highest at .876; region 3, South is next with r2 = .694; region 1 is Northeast with r2 = .672; and region 2, Midwest r2 = .439.

Scatterplots of Dependent Variable "Percent Gentrified" and City Level Characteristics
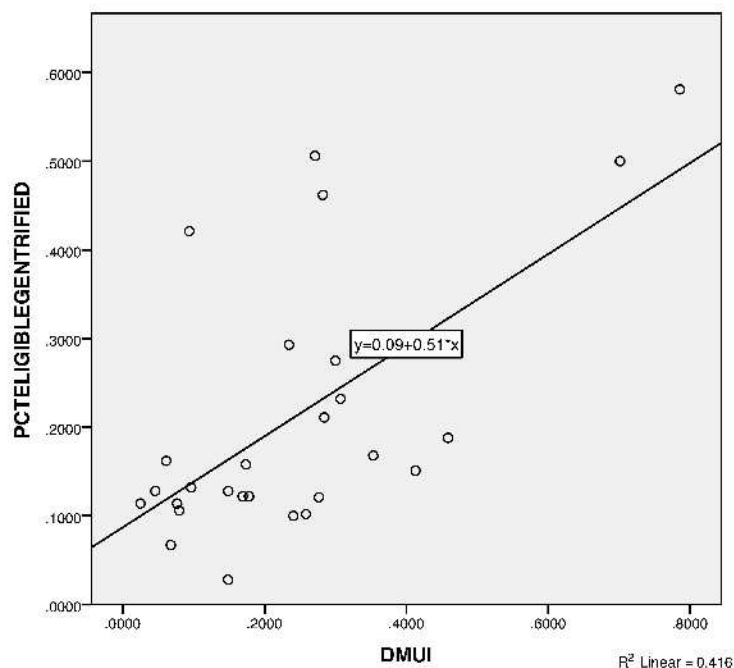
Fig. A6. Scatterplot for dependent variable percentage of tracts gentrified with percent change in HOLC "D" areas that are middle to upper income. This is a significant positive relationship with a high r2 of .416. This indicates that HOLC "D"-graded areas which are now middle-to-upper income are associated with higher levels of gentrification at the city level.
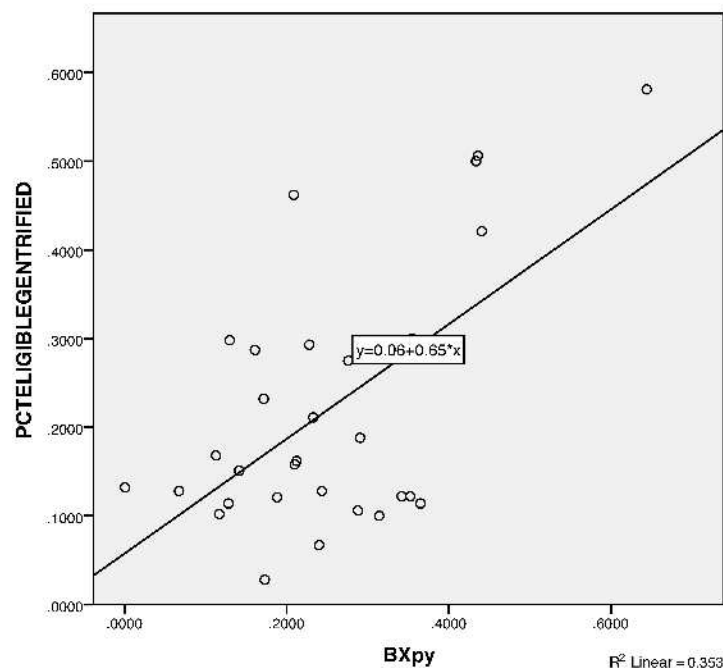
Fig. A7. Scatterplot for dependent variable percentage of tracts gentrified with percent change in cities with greater black interaction index. Significant positive relationship and an r2 of .353. This indicates that greater black interaction is associated with greater gentrification at the city level.
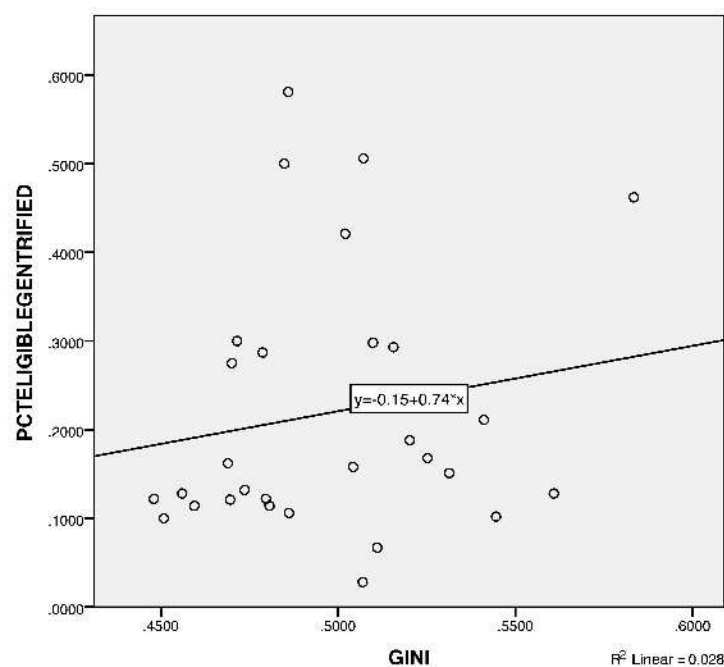
Fig. A8. Scatterplot for dependent variable percentage of tracts gentrified with Gini coefficient measuring economic inequality. This relationship is significant and positive in the regression model; however, it has a very low r2 of only .028 when presented as a scatterplot with line-of-fit.

Methodology

Example of Richmond Virginia 1937 HOLC map, digitized by the Mapping Inequality Project at the University of Richmond.
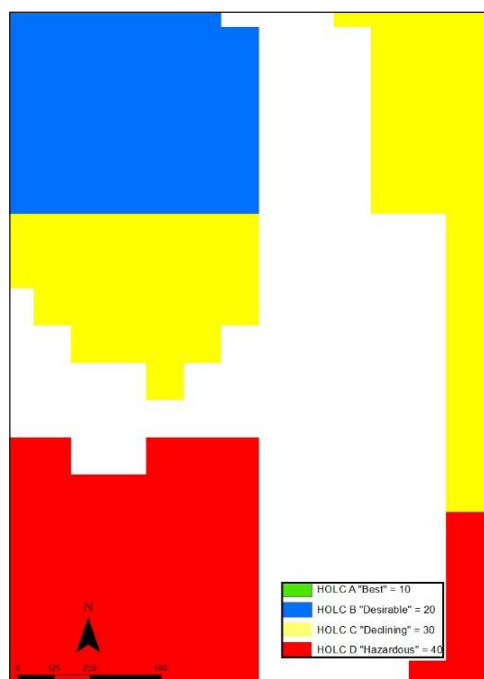
A1) Raster layer close-up with HOLC grades defining cells.
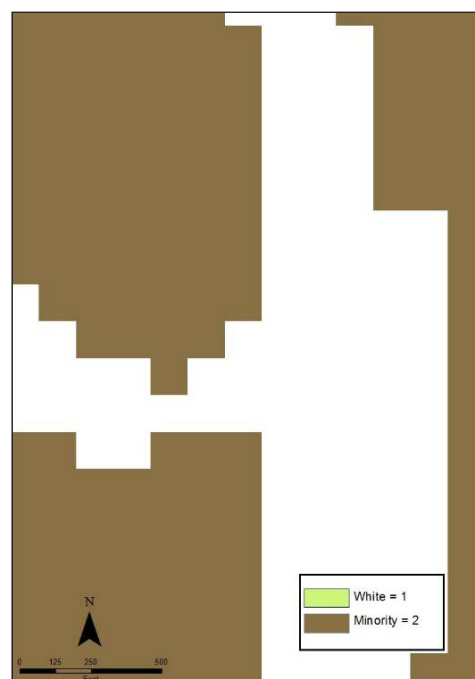
A2) Close-up of cells defining minority areas.
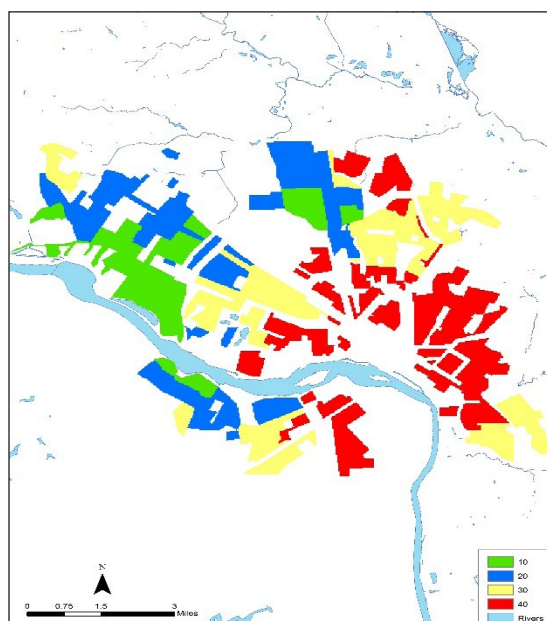
A 3) HOLC maps digitized and rasterized

A 4) 2016 FFIEC Income map clipped and rasterized

A5) Census 2010 minority and white areas clipped and rasterized

A6) Calculation of Income rasters

A7) Calculation of minority-majority rasters

All Data Used In Document

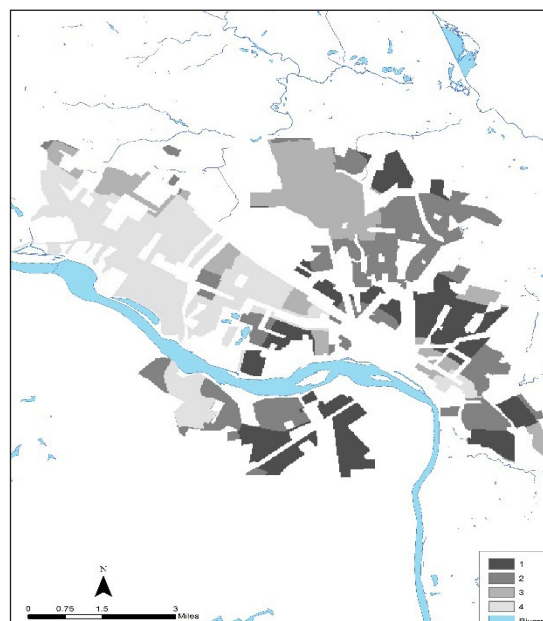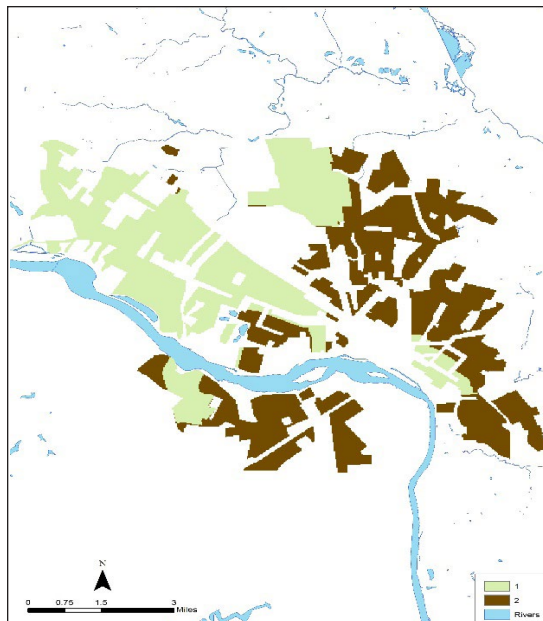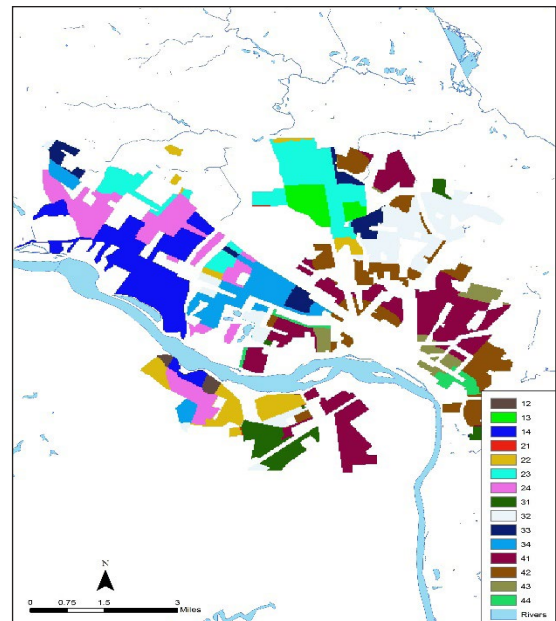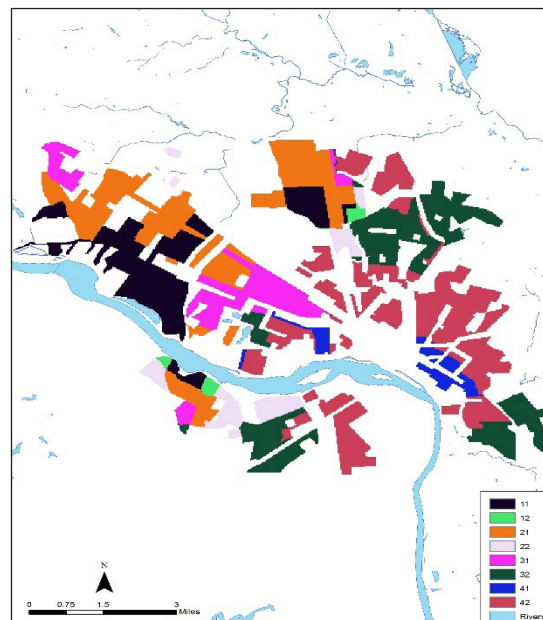| CITY	ANotMinority	BNotMinority	CMinority	DMinority	AMUI	BMUI	CLMI	DLMI	BID	B_xPy	HID	H_xPy	GINI	REGION	PCTMIN	PCTLMI
BINGHAMPTON NY	100%	100%	0%	0%	96%	57%	33%	100%	0.39	0.76	0.33	0.77	0.50	1	0%	93%
TRENTON	33%	45%	47%	100%	58%	53%	55%	100%	0.61	0.25	0.59	0.29	0.49	1	96%	94%
BUFFALO	97%	79%	49%	52%	92%	52%	82%	95%	0.69	0.29	0.52	0.53	0.46	1	42%	85%
STAMFORD	69%	72%	82%	100%	69%	67%	95%	94%	0.59	0.39	0.53	0.42	0.52	1	97%	84%
ROCHESTER	99%	68%	44%	92%	99%	72%	57%	93%	0.66	0.31	0.58	0.37	0.49	1	90%	80%
EAST HARTFORD	99%	35%	87%	88%	93%	28%	85%	90%	0.63	0.24	0.58	0.31	0.46	1	84%	71%
ALBANY	99%	88%	18%	47%	99%	71%	41%	89%	0.56	0.50	0.40	0.62	0.43	1	39%	70%
HOLYOKE	100%	82%	7%	10%	95%	24%	27%	87%	0.39	0.59	0.52	0.45	0.44	1	13%	68%
NEW HAVEN	75%	87%	50%	83%	100%	67%	49%	87%	0.61	0.31	0.55	0.35	0.52	1	78%	67%
ELMIRA	100%	100%	0%	0%	100%	73%	70%	77%	0.43	0.70	0.28	0.76	0.46	1	0%	46%
SYRACUSE	98%	81%	38%	46%	89%	59%	72%	77%	0.57	0.40	0.43	0.52	0.51	1	35%	45%
BOSTON CITY	93%	90%	56%	55%	0%	93%	54%	72%	0.68	0.23	0.57	0.34	0.54	1	46%	34%
MANCHESTER	100%	100%	0%	0%	100%	57%	44%	71%	0.35	0.78	0.37	0.76	0.43	1	0%	33%
ATLANTIC CITY	99%	65%	46%	76%	100%	98%	48%	71%	0.75	0.19	0.63	0.28	0.55	1	67%	33%
PITTSBURGH	100%	89%	26%	32%	100%	82%	58%	70%	0.64	0.43	0.27	0.73	0.53	1	22%	28%
JOHNSTOWN	0%	100%	0%	0%	0%	84%	47%	67%	0.57	0.77	0.29	0.85	0.45	1	0%	25%
ERIE	100%	100%	15%	31%	100%	81%	43%	64%	0.57	0.59	0.43	0.66	0.45	1	19%	19%
UTICA	100%	98%	14%	10%	90%	89%	39%	63%	0.57	0.56	0.51	0.60	0.48	1	12%	19%
PHILADELPHIA	70%	64%	51%	69%	94%	80%	51%	61%	0.74	0.16	0.65	0.26	0.48	1	59%	18%
NEW CASTLE	100%	100%	10%	32%	100%	97%	39%	60%	0.54	0.74	0.25	0.87	0.47	1	19%	17%
NEW YORK CITY	91%	56%	67%	69%	95%	71%	34%	53%	0.81	0.10	0.64	0.19	0.55	1	57%	11%
NEW YORK MSA	91%	78%	55%	68%	96%	88%	30%	52%	0.79	0.13	0.62	0.23	0.51	1	54%	10%
BOSTON_MSA	99%	94%	14%	17%	99%	91%	31%	42%	0.63	0.36	0.57	0.44	0.48	1	13%	7%
ALTOONA	100%	100%	0%	0%	100%	92%	22%	35%	0.34	0.92	0.20	0.93	0.45	1	0%	4%
HAMILTON	100%	100%	6%	56%	100%	33%	92%	100%	0.45	0.00	0.47	0.00	0.44	2	43%	93%
WARREN	100%	100%	18%	90%	100%	88%	84%	100%	0.38	0.58	0.15	0.70	0.48	2	83%	94%
KENOSHA	100%	100%	26%	36%	100%	59%	88%	99%	0.44	0.58	0.37	0.60	0.43	2	18%	93%
CANTON	100%	91%	24%	80%	89%	46%	88%	100%	0.43	0.61	0.24	0.73	0.45	2	69%	95%
LORAIN	0%	91%	50%	59%	0%	60%	94%	100%	0.40	0.46	0.39	0.47	0.45	2	47%	97%
DECATUR	88%	83%	36%	50%	86%	25%	78%	98%	0.49	0.52	0.27	0.67	0.46	2	38%	93%
WICHITA	57%	84%	30%	42%	57%	73%	72%	98%	0.54	0.37	0.36	0.47	0.46	2	30%	93%
GRAND RAPIDS	100%	85%	12%	47%	100%	81%	44%	96%	0.50	0.48	0.49	0.48	0.46	2	34%	92%
AURORA	86%	41%	89%	96%	87%	42%	85%	96%	0.29	0.34	0.46	0.24	0.43	2	90%	91%
KANSAS CITY	100%	75%	53%	72%	100%	70%	75%	95%	0.67	0.24	0.56	0.40	0.46	2	57%	91%
FORT WAYNE	100%	94%	35%	39%	100%	54%	86%	95%	0.57	0.37	0.40	0.49	0.45	2	26%	91%
SPRINGFIELD IL	100%	98%	2%	46%	100%	48%	92%	94%	0.47	0.51	0.22	0.68	0.48	2	32%	90%
CLEVELAND	84%	70%	43%	85%	95%	81%	49%	93%	0.70	0.24	0.51	0.57	0.51	2	76%	90%
GARY	41%	52%	65%	72%	64%	45%	58%	93%	0.72	0.18	0.42	0.42	0.50	2	57%	88%
TOLEDO	87%	64%	35%	77%	92%	60%	62%	92%	0.61	0.39	0.34	0.66	0.46	2	64%	87%
LIMA	100%	88%	13%	29%	90%	64%	62%	91%	0.38	0.63	0.24	0.71	0.46	2	20%	84%
MUNCIE	0%	100%	10%	46%	0%	85%	78%	91%	0.45	0.60	0.14	0.81	0.46	2	31%	84%
ST LOUIS	86%	50%	58%	69%	88%	43%	75%	90%	0.72	0.20	0.37	0.56	0.46	2	53%	81%
KALAMAZOO	100%	96%	30%	41%	89%	71%	74%	87%	0.37	0.53	0.29	0.62	0.50	2	29%	79%
SPRINGFIELD MO	100%	100%	0%	0%	99%	98%	64%	87%	0.22	0.83	0.12	0.84	0.44	2	0%	79%

CITY	ANotMinority	BNotMinority	CMinority	DMinority	AMUI	BMUI	CLMI	DLMI	BID	B_xPy	HID	H_xPy	GINI	REGION	PCTMIN	PCTLMI
MUSKEGON	100%	48%	75%	49%	100%	38%	75%	86%	0.65	0.36	0.36	0.58	0.47	2	33%	76%
BATTLE CREEK	100%	90%	16%	26%	100%	61%	72%	86%	0.48	0.57	0.32	0.68	0.48	2	17%	75%
AKRON	85%	80%	13%	53%	80%	53%	71%	85%	0.61	0.11	0.29	0.70	0.48	2	37%	74%
DETROIT	60%	36%	48%	73%	79%	65%	57%	85%	0.78	0.17	0.52	0.48	0.51	2	54%	73%
JOLIET	70%	66%	70%	81%	73%	54%	73%	85%	0.54	0.00	0.41	0.00	0.40	2	64%	71%
ROCKFORD	100%	95%	29%	67%	100%	70%	71%	85%	0.50	0.44	0.37	0.52	0.48	2	48%	71%
SOUTHBEND	95%	81%	48%	64%	95%	63%	71%	83%	0.50	0.49	0.47	0.50	0.48	2	45%	70%
INDIANAPOLIS	93%	83%	41%	27%	96%	42%	48%	83%	0.57	0.35	0.41	0.50	0.48	2	19%	70%
YOUNGSTOWN	70%	62%	35%	61%	83%	55%	68%	83%	0.67	0.39	0.49	0.53	0.48	2	44%	68%
DAYTON	86%	47%	32%	57%	86%	25%	81%	82%	0.73	0.26	0.30	0.70	0.49	2	41%	67%
COLUMBUS	91%	73%	40%	47%	89%	54%	68%	82%	0.63	0.34	0.41	0.56	0.45	2	32%	67%
TERRE HAUTE	100%	100%	0%	0%	99%	70%	60%	81%	0.39	0.76	0.31	0.78	0.46	2	0%	66%
PONTIAC	1%	57%	84%	79%	1%	57%	97%	79%	0.58	0.27	0.50	0.38	0.47	2	59%	62%
FLINT	100%	36%	52%	38%	100%	31%	78%	75%	0.63	0.28	0.25	0.62	0.49	2	21%	54%
MINNEAPOLIS	97%	82%	50%	53%	96%	63%	83%	73%	0.53	0.44	0.49	0.48	0.51	2	36%	46%
MILWAUKEE	88%	77%	47%	53%	88%	75%	56%	72%	0.79	0.19	0.58	0.40	0.47	2	35%	45%
PORTSMOUTH	100%	100%	0%	0%	100%	86%	73%	70%	0.56	0.84	0.25	0.91	0.48	2	0%	37%
EVANSVILLE	100%	33%	8%	25%	100%	20%	78%	70%	0.50	0.65	0.27	0.80	0.45	2	17%	36%
BAY CITY	100%	100%	0%	0%	100%	68%	19%	67%	0.40	0.84	0.24	0.86	0.46	2	0%	33%
SAGINAW	100%	96%	61%	52%	73%	96%	79%	66%	0.60	0.27	0.32	0.46	0.46	2	29%	27%
CHICAGO	100%	65%	58%	81%	100%	76%	49%	65%	0.81	0.11	0.62	0.27	0.53	2	54%	26%
SPRINGFIELD OH	98%	94%	14%	39%	96%	67%	69%	64%	0.51	0.54	0.30	0.66	0.44	2	20%	24%
MADISON	99%	100%	1%	10%	91%	91%	50%	60%	0.13	0.62	0.43	0.59	0.47	2	13%	23%
ST JOSEPH	82%	49%	64%	75%	100%	100%	0%	54%	0.35	0.80	0.25	0.82	0.44	2	43%	17%
OSHKOSH	0%	100%	0%	0%	0%	71%	19%	45%	0.15	0.90	0.11	0.90	0.43	2	0%	13%
RACINE	100%	100%	21%	38%	100%	87%	56%	41%	0.42	0.46	0.37	0.48	0.43	2	16%	9%
DULUTH	100%	100%	0%	0%	100%	78%	36%	16%	0.45	0.84	0.21	0.88	0.48	2	0%	0%
NEWPORT NEWS	0%	84%	83%	100%	0%	0%	100%	100%	0.46	0.12	0.30	0.18	0.43	3	93%	95%
DURHAM	85%	72%	66%	100%	85%	70%	61%	100%	0.57	0.16	0.42	0.25	0.48	3	93%	95%
MONTGOMERY	74%	53%	68%	99%	100%	92%	66%	99%	0.55	0.22	0.46	0.40	0.48	3	90%	95%
COLUMBUS	73%	62%	66%	76%	100%	71%	79%	99%	0.61	0.21	0.38	0.40	0.49	3	45%	95%
CHATTANOOGA	90%	65%	65%	76%	94%	66%	86%	97%	0.66	0.30	0.44	0.54	0.50	3	44%	95%
JACKSONVILLE	100%	78%	46%	90%	100%	76%	51%	94%	0.63	0.21	0.31	0.53	0.47	3	74%	95%
GREENSBORO	100%	98%	75%	93%	100%	98%	75%	93%	0.60	0.00	0.53	0.00	0.49	3	84%	95%
LYNCHBURG	100%	95%	84%	100%	99%	73%	96%	100%	0.47	0.44	0.20	0.62	0.49	3	94%	97%
LOUISVILLE	100%	78%	36%	57%	100%	73%	69%	92%	0.65	0.29	0.41	0.59	0.49	3	31%	94%
KNOXVILLE	97%	87%	30%	36%	93%	63%	75%	91%	0.52	0.50	0.31	0.69	0.50	3	15%	94%
OKLAHOMA CITY	30%	47%	0%	88%	13%	35%	0%	90%	0.53	0.00	0.44	0.00	0.47	3	70%	91%
WINSTON-SALEM	100%	54%	84%	97%	100%	55%	76%	86%	0.58	0.20	0.50	0.29	0.51	3	91%	84%
LEXINGTON	100%	100%	18%	41%	100%	71%	80%	85%	0.47	0.55	0.47	0.56	0.50	3	19%	84%
MIAMI	44%	21%	91%	99%	93%	72%	74%	85%	0.81	0.07	0.52	0.14	0.56	3	93%	83%
CHARLOTTE	96%	92%	56%	68%	97%	95%	59%	83%	0.69	0.21	0.56	0.38	0.50	3	38%	83%
MOBILE	100%	86%	39%	84%	100%	97%	23%	80%	0.69	0.13	0.38	0.34	0.50	3	64%	82%
NORFOLK	94%	86%	58%	83%	91%	75%	63%	88%	0.52	0.27	0.29	0.44	0.48	3	59%	89%
RICHMOND VA	93%	78%	66%	90%	96%	80%	61%	87%	0.66	0.20	0.41	0.42	0.54	3	77%	88%

CITY	ANotMinority	BNotMinority	CMinority	DMinority	AMUI	BMUI	CLMI	DLMI	BID	B_xPy	HID	H_xPy	GINI	REGION	PCTMIN	PCTLMI
TAMPA	100%	84%	46%	83%	100%	84%	41%	79%	0.65	0.22	0.49	0.37	0.54	3	64%	88%
BIRMINGHAM	100%	60%	75%	86%	100%	78%	73%	78%	0.69	0.16	0.51	0.38	0.50	3	67%	88%
DALLAS	95%	50%	94%	87%	96%	54%	93%	74%	0.77	0.12	0.69	0.17	0.54	3	70%	74%
MACON	20%	70%	71%	91%	100%	86%	57%	73%	0.54	0.22	0.32	0.37	0.50	3	82%	68%
AUGUSTA	100%	81%	50%	78%	100%	52%	48%	74%	0.50	0.30	0.35	0.46	0.47	3	67%	71%
NEW ORLEANS	85%	77%	49%	76%	96%	86%	45%	72%	0.66	0.21	0.35	0.48	0.57	3	65%	65%
ATLANTA	100%	87%	54%	82%	100%	89%	47%	72%	0.66	0.21	0.55	0.36	0.58	3	68%	63%
ASHEVILLE	100%	96%	3%	42%	100%	84%	59%	70%	0.41	0.65	0.31	0.75	0.48	3	33%	61%
BALTIMORE	56%	39%	53%	69%	65%	42%	74%	69%	0.70	0.17	0.41	0.48	0.51	3	59%	53%
WHEELING	100%	100%	0%	0%	100%	100%	5%	67%	0.41	0.86	0.22	0.91	0.51	3	0%	50%
ST PETERSBURG	100%	81%	32%	39%	100%	95%	36%	56%	0.67	0.34	0.20	0.71	0.48	3	27%	33%
ROANOKE	100%	100%	24%	21%	100%	43%	70%	45%	0.59	0.41	0.38	0.65	0.46	3	21%	21%
CHARLESTON, WV	100%	93%	5%	7%	100%	58%	14%	33%	0.46	0.68	0.23	0.78	0.53	3	15%	15%
STOCKTON	68%	6%	100%	100%	78%	25%	95%	100%	0.53	0.16	0.43	0.17	0.47	4	92%	100%
OAKLAND	99%	62%	71%	94%	99%	83%	50%	77%	0.58	0.23	0.58	0.20	0.52	4	91%	73%
SAN JOSE	71%	63%	73%	91%	71%	89%	59%	76%	0.34	0.31	0.43	0.25	0.45	4	90%	70%
SACRAMENTO	96%	72%	48%	54%	96%	71%	50%	67%	0.46	0.35	0.39	0.37	0.47	4	33%	44%
PORTLAND	100%	100%	4%	0%	100%	92%	49%	21%	0.47	0.64	0.31	0.68	0.49	4	0%	0%
FRESNO	65%	7%	98%	100%	100%	44%	91%	92%	0.43	0.13	0.38	0.14	0.48	4	100%	100%
DENVER	100%	95%	20%	67%	100%	94%	45%	91%	0.53	0.44	0.54	0.36	0.50	4	50%	100%
SPOKANE	100%	100%	0%	0%	93%	85%	50%	78%	0.23	0.82	0.14	0.83	0.47	4	0%	100%
TACOMA	100%	98%	23%	47%	100%	94%	42%	73%	0.31	0.54	0.34	0.53	0.45	4	0%	100%
SAN DIEGO	100%	94%	39%	90%	99%	91%	51%	70%	0.58	0.28	0.56	0.27	0.47	4	100%	100%
LOS ANGELES	75%	55%	77%	88%	100%	85%	46%	59%	0.69	0.14	0.64	0.14	0.53	4	100%	100%
SAN FRANCISCO	77%	22%	44%	69%	99%	91%	14%	54%	0.56	0.29	0.48	0.32	0.52	4	100%	100%
SEATTLE	98%	92%	50%	66%	100%	93%	31%	30%	0.60	0.43	0.36	0.56	0.48	4	100%	100%

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