

EFFECTS OF REDLINING IN THE TWIN CITIES

By

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## LIST OF ABBREVIATIONS

HOLC	Home Owners' Loan Corporation (HOLC)
FHA	Federal Housing Administration
Twin Cities	Minneapolis and St. Paul, Minnesota
NHGIS	National Historic Geographic Information System

## ABSTRACT

The depression era Home Owners' Loan Corporation (HOLC) bought troubled mortgages from banks and refinanced mortgages with borrowers directly. The HOLC also graded neighborhoods by risk of mortgage default using racist criteria in a process now commonly called redlining. Scholarly work indicates that redlining resulted in adverse socioeconomic conditions in the decades since the depression. This study examines the possible long-term effects of redlining in the Twin Cities, Minneapolis and St. Paul, Minnesota, using decennial census and American Community Survey data. Trends were identified using socioeconomic measures at the census tract level in four areas: population, housing and rent, employment, and income. Analysis including geographically weighted regression identified significant variation in measures between best and worst rated tracts. As a percentage of a tract's population, non-White population grew while the White population declined. However, non-White population grew mostly in census tracts with the lowest HOLC grades. Home values in the lowest graded tracts increased over time yet lagged well behind better graded areas. Median rents in worst graded tracts doubled when compared to other tracts. The best graded area outpaced median income growth in all other tracts. Generally, the influence of HOLC grades was less in later census years. While regression analysis of median home value using the selected census data failed to provide a reliable predictive model, useful explanatory variables were identified for future study. Overall, the results show that multiple adverse socioeconomic conditions continue to exist in formerly redlined areas.

Keywords: redlining, HOLC, census, Minnesota, Minneapolis, St. Paul, socioeconomic trends



## ETHICS STATEMENT

Ethical practice in geospatial information science (GIS) and cartography centers on striving to produce accurate, understandable, unbiased products with proper source credits. GIS and map products must be accurate for beyond simply scholarly reasons. Unique to cartography, maps are, to various degrees, inherently inaccurate as they represent a three-dimensional ellipsoid environment on a two-dimensional surface. GIS professionals must overcome inherent challenges while producing accurate products since inaccuracy can cause serious problems for unsuspecting users. They must use analytical and statistical techniques they understand and can use correctly in the interest of accuracy. Yet, the most accurate product is useless if it cannot be understood. The GIS professional and cartographer must understand the purpose and audience of their product. They must also use clear and audience appropriate terms and symbols in their products. In the choice of data to include, terms to use, and symbols to show, GIS professionals must not introduce bias, misinformation or disinformation. They should also be sensitive to their audience's cultural concerns and preferences when designing their product. Fundamental to any scholarly effort are properly cited sources. It is appropriate to give credit to others hard work. Citing sources is also important to provide an effective audit trail, allowing others GIS professionals to evaluate and expand on one's products.

This project studies how government policies of a racist nature may have affected populations where the policies were implemented. Much research exists that shows how racist policies and prejudices have negatively impacted Black Americans. Knowing these negative impacts, I needed to guard against bias by assuming negative impacts would be identified in this study. I also needed to guard against concluding too

much from the GIS and statistical methods used in this project. To address these concerns, I conducted an extensive literature review with a focus on diverse methods and views, chose widely available and reputable U.S. Census data, and used reliable GIS and statistical methods that I am capable of implementing correctly. Through these steps and by adhering to ethical principles outlined above, I have endeavored to build on the work of others while producing my own original analysis.

## INTRODUCTION

The federal government first entered the market for residential mortgages in the 1930s with two major programs: the Home Owners' Loan Corporation (HOLC) in 1933 and the Federal Housing Administration (FHA) in 1934. The Home Owners' Loan Act of 1933 established the HOLC as part of President Franklin Roosevelt's New Deal programs during the Great Depression. The HOLC's bought distressed mortgages from banks to help prevent bank failures. The HOLC also dealt directly with homeowners by refinancing mortgages in default. For the first time in American home lending HOLC loans offered full amortization, extended loan durations, and caps on interest rates. Approximately one million refinancing loans were made by the HOLC with a 2022 inflation adjusted value of over \$64 billion U.S. dollars. More than 70 percent of all HOLC loans were issued before March 1935 (Harriss, 1951). Both organizations employed racist practices.

Between 1936 and 1940 the HOLC produced residential security maps. The maps intended to guide lending decisions by assigning a risk level to residential areas in 239 U.S. cities. The HOLC solicited local real estate and banking officials to grade neighborhoods A to D, with A being best and D being worst. Each area was also assigned a color code, "A-Best"/green, "B-Still Desirable"/blue, "C-Definitely Declining"/yellow, and "D-Hazardous"/red. Type and condition of a neighborhood's housing stock was a major factor in grading. The presence of non-white races, particularly the presence of Black Americans, also contributed to neighborhoods receiving the lowest grade of "red". This process is now commonly called redlining.

For example, the HOLC Map description for D8 in Figure 1-1 begins: "This is the Ghetto District - Russians, Jews, Mexicans, Chinese, and riff-raff live here, the most

undesirable district in St. Paul” (Richardson, Meier, Mitchell, Edlebi, & Lynch, 2020).

Note this is the area of St. Paul, Minnesota where the author’s maternal family lived for much of the 20th century.

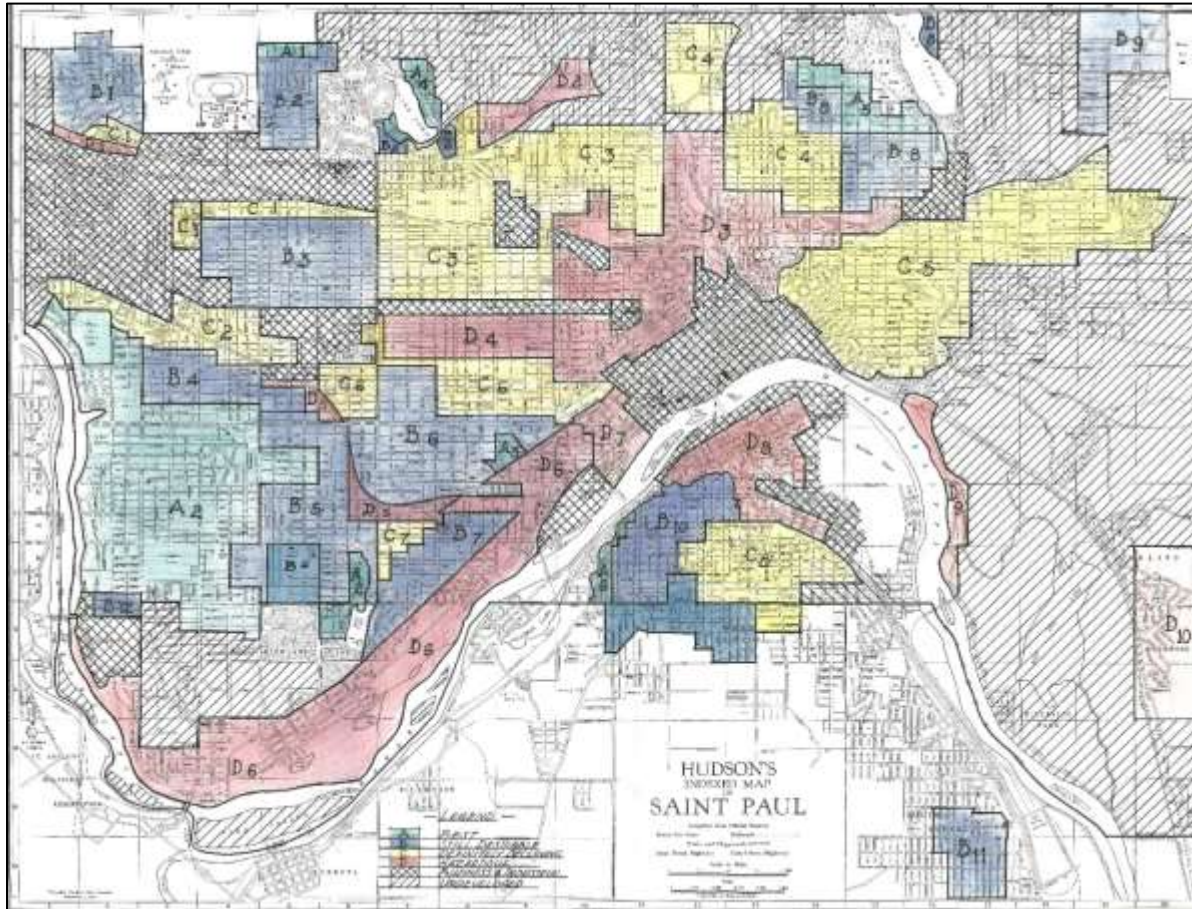


Figure 1-1. HOLC Map for St. Paul, Minnesota

D-8. This is the Ghetto District - Russians, Jews, Mexicans, Chinese, and riff-raff live here, the most undesirable district in St. Paul. The average age is 45 years. Much reconditioning is necessary, also very inadvisable. Depreciation in D-3, D-6, D-7 and D-8 took place prior to the depression and values have not and will not recover. Ownership is 20%. The rentals are whatever can be obtained on small units from \$5.00 up. Frame construction predominates. There are many combination commercial and residences. This district is comprised of tenements of three and four rooms and homes with two, three and four families living in them. It is a low class of development which has little or no value except as tenements. It is adjacent to the air port which is an outstanding one and less than 1 1/2 miles to the business district of St. Paul.

Figure 1-2. Image of original HOLC Map Description for D8 (Figure 1-1) in St. Paul, Minnesota.

Like the HOLC, officials at the Federal Housing Administration (FHA) also created neighborhood appraising and loan policies. FHA policies essentially mirrored policies put forth by the American Eugenics Society (AES) in the beginning of the 20<sup>th</sup> Century (Lovett, 2020). The AES viewed urbanization as problematic because of lower birth rates and delayed marriages among urban residents. They favored policies that promoted single family homes and suburban conditions which were believed to promote larger White families. Concurrently, the Great Migration was in progress. As Black Americans migrated from southern states to urban centers, lenders and appraisers saw the proximity of people of color in a neighborhood as decrement to home values. The FHA practiced redlining by generally not underwriting mortgages in low-income urban neighborhoods where the vast majority of urban Black Americans lived. This practice would not change until the civil rights movements in the 1960s.

Beginning in the 1960s and 1970s a series of U.S. federal laws prohibited racist appraising and lending practices. The Poverty & Race Research Action Council argues that despite changes in law the FHA and the private banking institutions continued a de facto redlining. This was done by issuing loans to Blacks Americans and people of color with predatory loan practices in form of 'sub-prime' mortgages. The mortgages were eventually bundled into mortgage-backed securities that ultimately led to the financial crisis in 2007 to 2008 and subsequent Great Recession (Harble & House, 2021).

The effects of redlining have seen substantial study, particularly since the HOLC maps were discovered in the 1970's and 80s. Kenneth T. Jackson's *Race, Ethnicity, and Real Estate Appraisal: The Home Owners Loan Corporation and the Federal Housing Administration* (Jackson, 1980) was one of the earliest scholarly examinations

of HOLC redlining. Using housing data from St. Louis, Missouri and Newark, New Jersey, the author detailed a consistent practice of the HOLC more negatively grading areas because of the presence of African Americans. The author explains how HOLC maps were adopted by the Federal Housing Administration (FHA), and using the HOLC grades, the FHA severely limited lending to black and urban areas. The author argues that FHA redlining practices facilitated home ownership by the middle class in suburban areas while hastening the decay of urban and minority populated neighborhoods.

The FHA's lending practices began prior the creation of HOLC's maps. Since the FHA lending practices were excluding Black Americans and people of color, like the HOLC maps suggested, the influence of HOLC maps on the FHA is unclear. (Fishback, Rose, Snowden, & Storrs, 2021). Nonetheless, according to the Institute for Policy Studies, the FHA's loan underwriting practices from 1934 to 1968 resulted in homebuyers of color receiving just 2% of the government-backed mortgages issued over that period. Since homeownership contributes to net worth, the report's authors argue that HOLC and FHA policies contributed to a racial wealth divide today. (Asante-Muhammad, Collins, Hoxie, & Nieves, 2017).

Research studying the effects of redlining in Indianapolis, Indiana found that HOLC letter grades explain 85% of segregation in Indianapolis neighborhoods. They also found that redlining explains over half of the difference in median income between A graded and D graded neighborhoods (Townsend, Andres, & Nowlin, 2012). Jacob Faber showed that HOLC graded areas are associated with segregation that has persisted into the 21<sup>st</sup> century (Faber, 2020). HOLC grades were also positively

associated with larger quantities of multifamily housing, and negatively associated with home values and rents (An, Orlando, & Rodnyansky, 2019).

Some studies have looked at effects beyond those associated with home values and rents. There is an association with redlined areas and present-day firearm violence in some cities (Mehranbod, et al., 2022). Another study found association between HOLC grades and COVID-19 risk factors (Richardson, Meier, Mitchell, Edlebi, & Lynch, 2020). Yet another recent study found a negative association HOLC grades and measures of opportunity and mobility, mental and physical health, and life expectancy (Noelke, et al., 2022).

Studies have also attempted to determine if HOLC maps caused the negative effects noted previously, or did the maps merely document existing conditions. The results are mixed. Amy Hillier's *Redlining and the Home Owners' Loan Corporation* examines mortgage lending in Philadelphia (Hillier, 2003). Based on spatial and statistical analysis, the author found that HOLC grades did not explain differences in lending patterns, except for interest rates that were higher in D (red) rated areas. The author concludes that HOLC maps represent a federal endorsement and promotion of already existing real estate appraisal practices and racial prejudice.

Researchers at the Federal Reserve Bank of Chicago found that the HOLC maps had causal effect in urban housing markets. These effects include reduced homeownership, values, rents and increased Black populations in C and D graded areas. They noted that the effects of the maps declined over time beginning in the 1970s and 1980s. (Aaronson, Hartley, & Mazumder, 2020)

While evidence clearly shows the FHA's discriminatory lending practices, the HOLC made many loans to poorly graded neighborhoods and Black homeowners (Fishback, Rose, Snowden, & Storrs, 2021). HOLC loaned to Black Americans at rates proportional to their share of the population. Yet, since Black Americans entered the depression financially worse off than White Americans, the New Deal program did not address the existing wealth gap (Michney & LaDale, 2020).

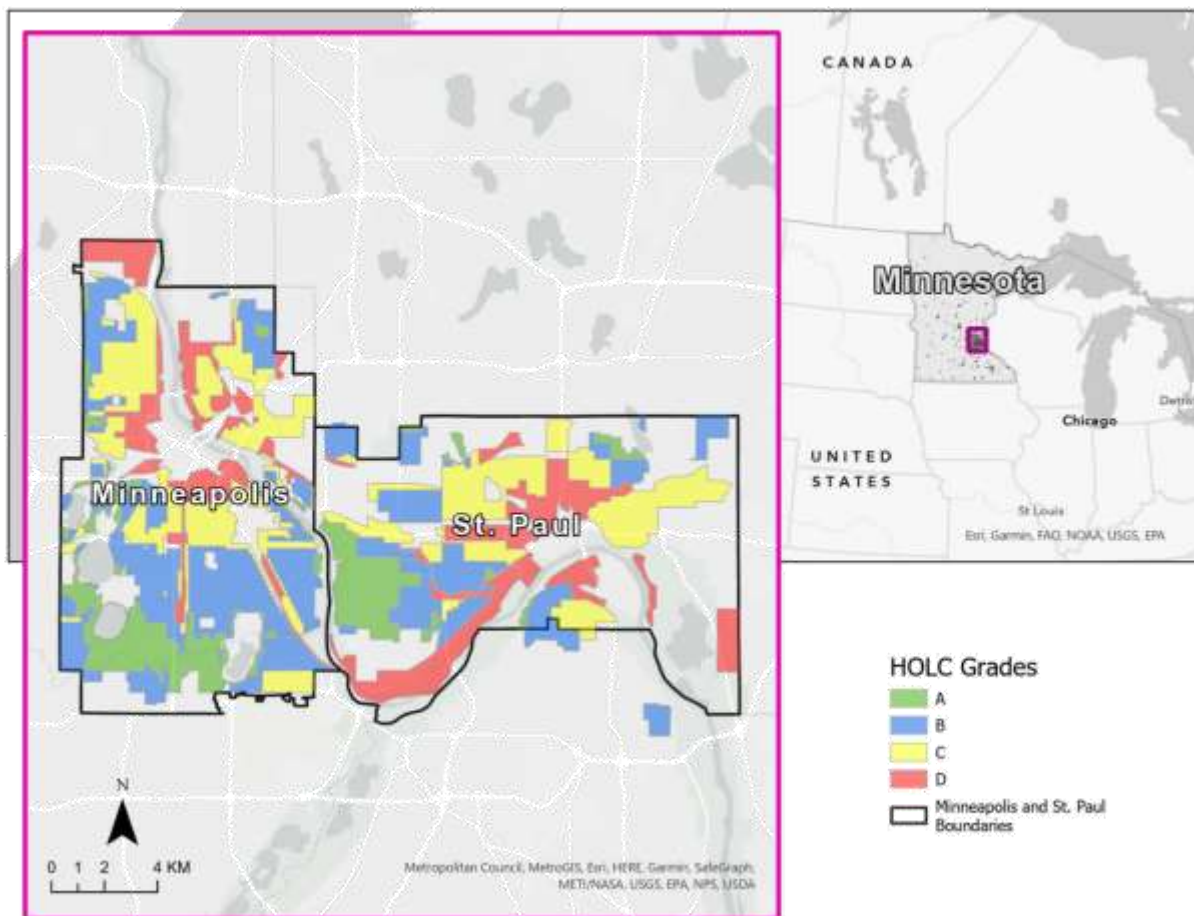


Figure 1-3. Study area: Twin Cities of Minneapolis and St. Paul, Minnesota

The Twin Cities was chosen as the study area for several reasons. Tract level census data exists in both cities from 1940 onward facilitating a multi-year study. A small number of Black Americans lived in the Twin Cities when the HOLC Maps were



made. This allows an opportunity to see how redlining affected neighborhoods with an initially small Black American population. The murder of George Floyd in May 2020 in Minneapolis triggered large, and sometimes violent, protests nationwide. These events highlight the racial tensions present in the Twin Cities. Lastly, the author has a personal interest in the study area as that is where they were born, raised, and graduated from the University of Minnesota.

Research (Aaronson, Hartley, & Mazumder, 2020) (Townsend, Andres, & Nowlin, 2012) suggests that redlining effects in the Twin Cities may include: concentration of Black Americans in red graded areas, large gaps in median income between best and worst rated areas, lower rents and home values, and lower rates of owner-occupied housing in worst graded areas. That same research also suggests that the effects of HOLC grades will decay over time.

This study does not distinguish between actions of the HOLC or the FHA. It seeks only to measure potential negative socioeconomic effects over time in Minneapolis and St. Paul, Minnesota using areas that were graded by the Home Owners' Loan Corporation (HOLC) in the late 1930s as criteria. There are five objectives to this study:

1. Define consistent socioeconomic measures for each census year from 1940 to 2020.
2. Determine how these variables changed over time.
3. Compare changes in variables between best and worst graded areas.
4. Perform spatial regression analysis on selected measures.
5. Identify areas for potential future study.

## METHODS AND DATA

### Methods

Several studies have looked at current socioeconomic data in examining the effects of redlining. There are advantages to this method as more data from recent years is digitized and easily accessible. For example, the U.S. Census Bureau published detailed data at the block level starting from 2000 at the website <https://data.census.gov>.

However, more than eighty years have passed since the HOLC redlining maps were produced. Measuring recent socioeconomic measures does not address how those measures changed over time. To assess that change, this study uses U.S. census data from 1940 to 2020. Despite changes in survey questions from census to census, several socioeconomic measures (Table 2-1) were sufficiently alike allowing year to year comparison.

Table 2-1. Socioeconomic Measures

Category	Sub-Category	Measures Per Tract
Population	Total	Total
	Racial Composition	% Black/African American, % Other Races
Housing	Tenure	% Owner and % Renter Occupied
	Value	Median Home Value Adjusted
	Rent	Median Gross Rent (rent + utilities)
Employment Income	Employment	% of Labor Force Employed
	Family Income	Median Family Income

The basic analysis method is as follows (Figure 2-1): 1) assign HOLC grades to census tracts for each study year, 2) generate tables to show trends in socioeconomic measures over time, 3) select measures for regression analysis.

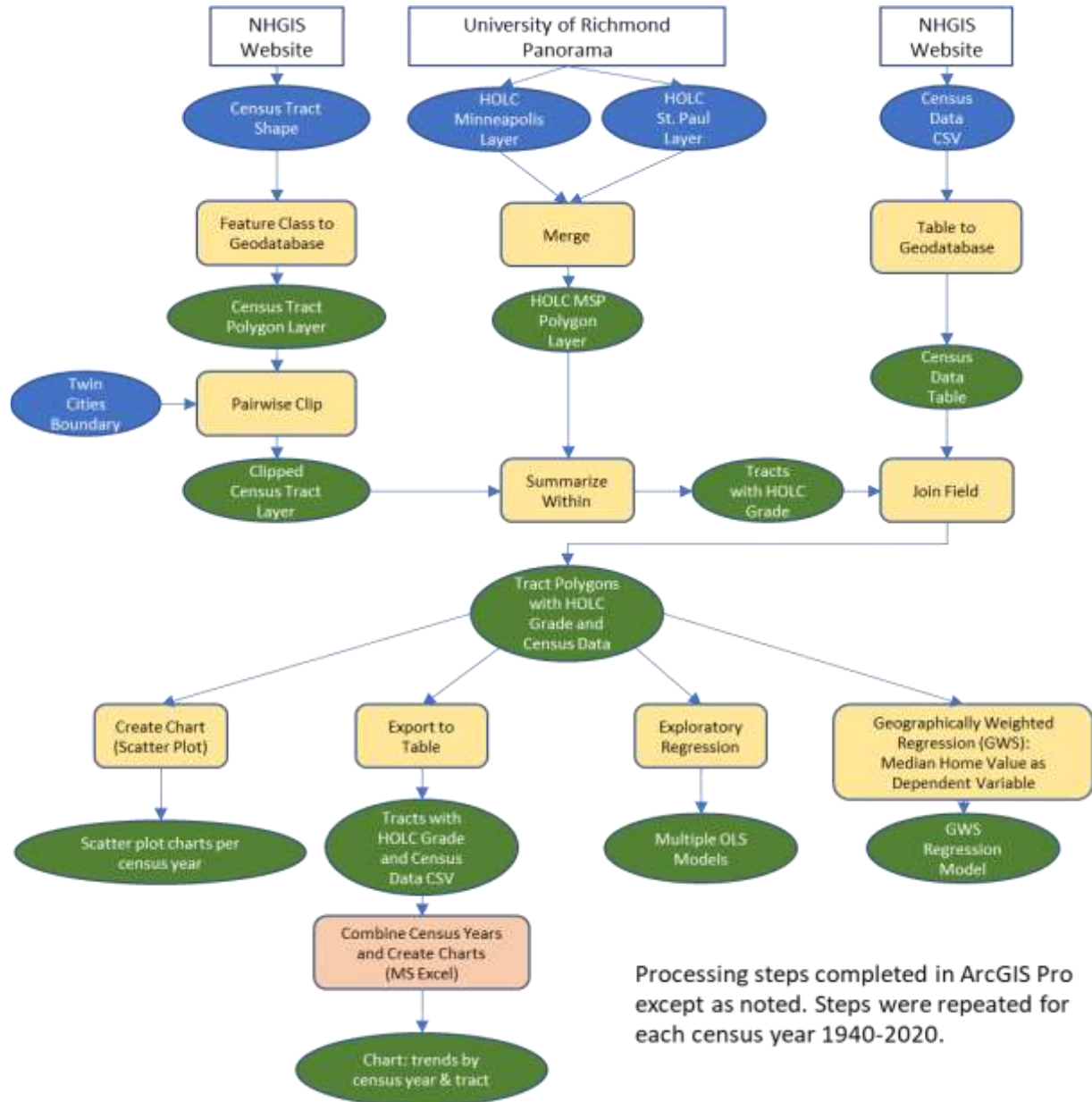


Figure 2-1. Workflow

The University of Richmond’s Digital Scholarship Lab published shape files derived from the original HOLC residential security maps as part of their *Mapping Inequality: Redlining in New Deal America* project. The shapefiles for Minneapolis and

St. Paul, Minnesota were imported into Esri ArcGIS Pro 3.0 with the Feature Class to Geodatabase tool and combined with the Merge tool (Nelson, Winling, Marciano, & Connolly, 2022).

Next, shapefiles for census tracts for each census year were also imported into ArcGIS Pro, again using the Feature Class to Geodatabase tool. The files were limited to city boundaries for Minneapolis and St. Paul using the Pairwise Clip tool. Two small HOLC graded areas were outside the boundaries of Minneapolis and St. Paul and were excluded from analysis.

The lowest level census data available for both Minneapolis and St. Paul begins in 1940 with census tract records. The U.S. Census Bureau has only published tract shapefiles for 2006 and later. However, the IPUMS (Integrated Public Use Microdata Series) National Historical Geographic Information System (NHGIS) housed at the University of Minnesota provides historical census shape files. NHGIS used U.S. Census 2000 TIGER/Line data as a starting point when creating the historical tract files. Historical boundaries that coincided with 2000 boundaries were retained while the missing boundaries were digitized from the original published reports. For 2010 and 2020, NHGIS tract shapefiles use U.S. Census TIGER/Line data directly (Adams, et al., 2022).

The next step was to assign an HOLC grade to each census tract in each census year. HOLC graded areas do not follow tract boundaries. Some tracts contain areas with multiple HOLC grades. Literature review (Mehranbod, et al., 2022) (Faber, 2020) identified methods for assigning an HOLC grade. This study computes the percentage land area for each HOLC grade within a tract using the Summary Within tool. The grade

associated with the largest area is assigned as the tract’s HOLC grade. This was judged sufficient for this project’s intent of identifying possible negative socioeconomic effect and possible future areas of study. A more detailed analysis would require advanced statistical techniques to examine the effects of multiple HOLC grades within a census tract.

NHGIS also publishes U.S. Census data in comma separated value (csv) files. The data was normalized to allow year to year socioeconomic measure comparison using Microsoft Excel. Counts within a census tract were converted to percentages of the total count. Dollar amounts were adjusted to 2020 dollars using U.S. Bureau of Labor Statistics (BLS) Consumer Price Index (Table 2-2) for All Urban Consumers (CPI-U) (U.S. Bureau of Labor Statistics, 2022).

Table 2-2. CPI Data File

Official Name of Data Set	CPI for All Urban Consumers (CPI-U) CUUR0000SA0
Year of Publication	2022
Author and/or Owner	U.S. Bureau of Labor Statistics
URL or FTP address	<a href="https://data.bls.gov/cgi-bin/surveymost?cu#TB_inline?height=400&amp;width=500&amp;inlineId=survey_links">https://data.bls.gov/cgi-bin/surveymost?cu#TB_inline?height=400&amp;width=500&amp;inlineId=survey_links</a>
Description	Microsoft Excel workbook with monthly and annual average CPI from 1940 to 2022.

The formula used with the CPI index was:

$$\text{Dollar Value in } X = \text{Dollar Value in } Y \text{ (CPI}_X\text{/CPI}_Y\text{)}$$

*where X and Y are years.*

Each census table was imported into ArcGIS using the Table to Geodatabase tool and aliases were assigned using the Bulk Assign Aliases tool. Since csv files stored number values as text, the Feature Class to Feature Class tool was used to convert numbers to short integers. The census data was joined with the tract polygons.

The average of each socioeconomic measure for each HOLC grade (A, B, C, D) was then calculated. These averages were then charted for each census year to identify trends overtime. Measures showing significant differences between the best and worst HOLC grades or significant trends over time were selected as dependent variables for regression.

Regression analysis used dependent and independent variables from the same census year. This was due to the changes in census tract numbers, population totals, and types of survey questions from census to census. This single year method was deemed sufficient for this study as regression results using the same variables can be compared from year to year to identify trends. Median inflation adjusted house value was used as the dependent variable since home values are a large component of generational wealth. HOLC grade was an independent variable along with other measures from that census year.

In each year, the Exploratory Regression tool was used in ArcGIS. This tool performs a series of ordinary least squares (OLS) regression to identify the most suitable sets of independent variables based on the results of Adjusted R Squared, P-values, VIF and Jarque-Bera scores. The Geographically Weighted Regression (GWR) tool was run with the best fit set of independent variables from OLS because the data was spatially autocorrelated. The GWR tool allows for consideration of spatially varying relationships by performing a series of regression models repeated in a local neighborhood for each feature (ESRI, 2022) instead of the global model created by OLS.

## Data

The NHGIS 1940 through 1960 census tract tables were generated from the Elizabeth Mullen Bogue Files Series, a digital file set that was generated from original U.S. Census publications (Bouge, 2006). Tract data NHGIS tract tables were derived directly from U.S. Census Bureau computer files for years after 1970. NHGIS census shape files through 1980 used the U.S. Census Bureau 2000 TIGER/Line files as a base with scanned geo-referenced boundaries from original published census reports. They are projected to USA Contiguous Albers Equal Area Conic projection, in meters and NAD83 (see Appendix A for details on each census data set). Upon import for this project, the tract files were converted to NAD 1983 UTM Zone 15N (26915) which is more suited to study area.

The Mapping Inequality shape files (Table 2-3 and 2-4) were created from original HOLC maps which were scanned and georectified. Shapefiles were then generated. These files were downloaded in the GSC WGS 1984 but converted to NAD 1983 UTM Zone 15N (26915) for the project.

Table 2-3. Minneapolis HOLC Graded Areas File

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Official Name of Data Set	Mapping Inequality - Minneapolis
Year of Publication	2017
Author and/or Owner	University of Richmond Digital Scholarship Lab
Original Creator	U.S. Govt Home Owners' Loan Corporation via the National Archives
URL or FTP address	<a href="http://dsl.richmond.edu/mappinginequality.html">http://dsl.richmond.edu/mappinginequality.html</a>
Description	Shape file denoting boundaries of HOLC graded neighborhoods.
Coordinate System	WGS 1984 (4326), Datum WGS 1984
Projection System	None
Type of Geometry	Polygon

Table 2-4. St. Paul HOLC Graded Areas File

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Official Name of Data Set	Mapping Inequality – St. Paul
Year of Publication	2017
Author and/or Owner	University of Richmond Digital Scholarship Lab

---

Original Creator	U.S. Govt Home Owners' Loan Corporation via the National Archives
URL or FTP address	<a href="http://dsl.richmond.edu/mappinginequality.html">http://dsl.richmond.edu/mappinginequality.html</a>
Description	Shape file denoting boundaries of HOLC graded neighborhoods.
Coordinate System	WGS 1984 (4326), Datum WGS 1984
Projection System	None
Type of Geometry	Polygon



## RESULTS

### Results and Trends

The total population in Minneapolis and St. Paul in 2020 is slightly lower than it was during the 1940 Census. This is likely a result of the substantial suburban growth in the Twin Cities metropolitan area during this time frame. The total population declined 25% from 1950 to 1980 (Figure 3-1, Appendix C for data tables for each chart) and experienced growth in 1990 and 2010 censuses. However, during this time, populations of Black Americans and other people of color saw sustained growth in urban areas.

The Black population in Minneapolis and St. Paul grew increasingly concentrated in red and yellow tracts between 1940 and 2000 (Figure 3-2). In the 1940 Census, the overall percentage of Black population was 3.6% in tracts with a HOLC majority grade D/red. This was by far the largest percentage of Black people in the study area in the 1940 census. The Black population grew slowly until the 1970 when its growth accelerated. By the 2010 Census growth plateaued at 25% in red tracts. Substantial growth also occurred in yellow tracts, and by 2010, 23.7% of the population was Black. While the percentage of Black population grew in the green and blue tracts, it was limited.

The rate of growth for other races increased beginning in 1970. By the 2020 Census, other races made up 33% of the population in yellow tracts, and 20% in red areas (Figure 3-3). Population of other races grew at a rate greater than Black Americans in green and blue tracts. Figures 3-4 and 3-5 show race by census tract in 1940 and 2020.

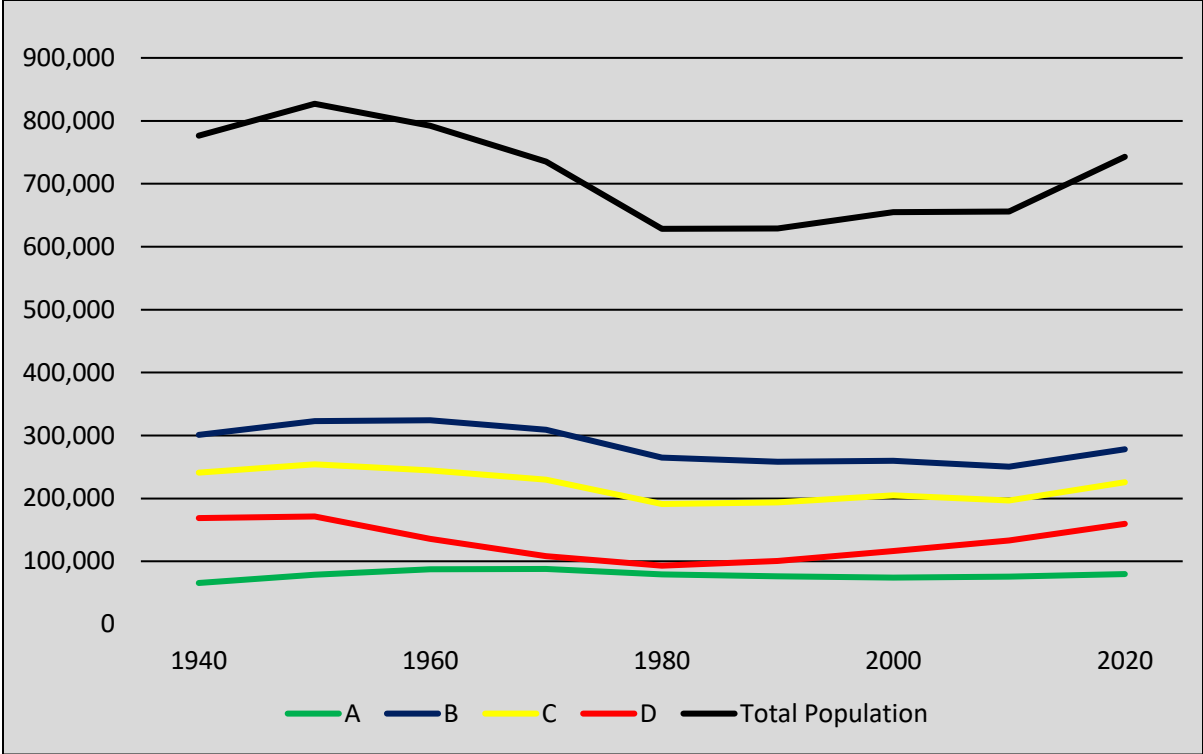


Figure 3-1. Total Population by Year and Tract HOLC Grade

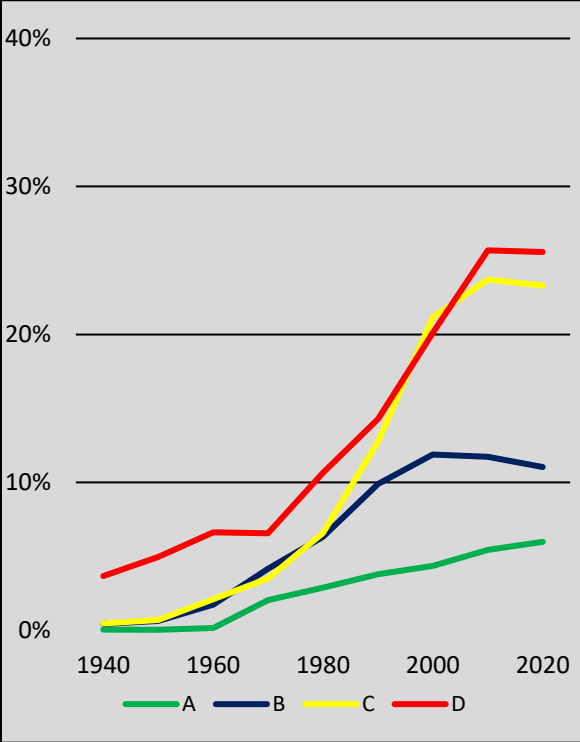


Figure 3-2. Percent Black, African American Population by Year and Tract HOLC Majority Grade

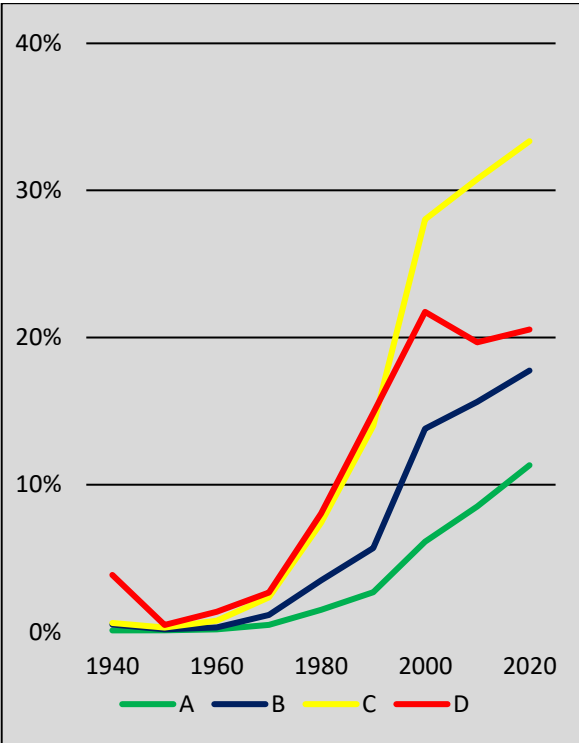


Figure 3-3. Percent Other Races by Year and Tract HOLC Majority Grade

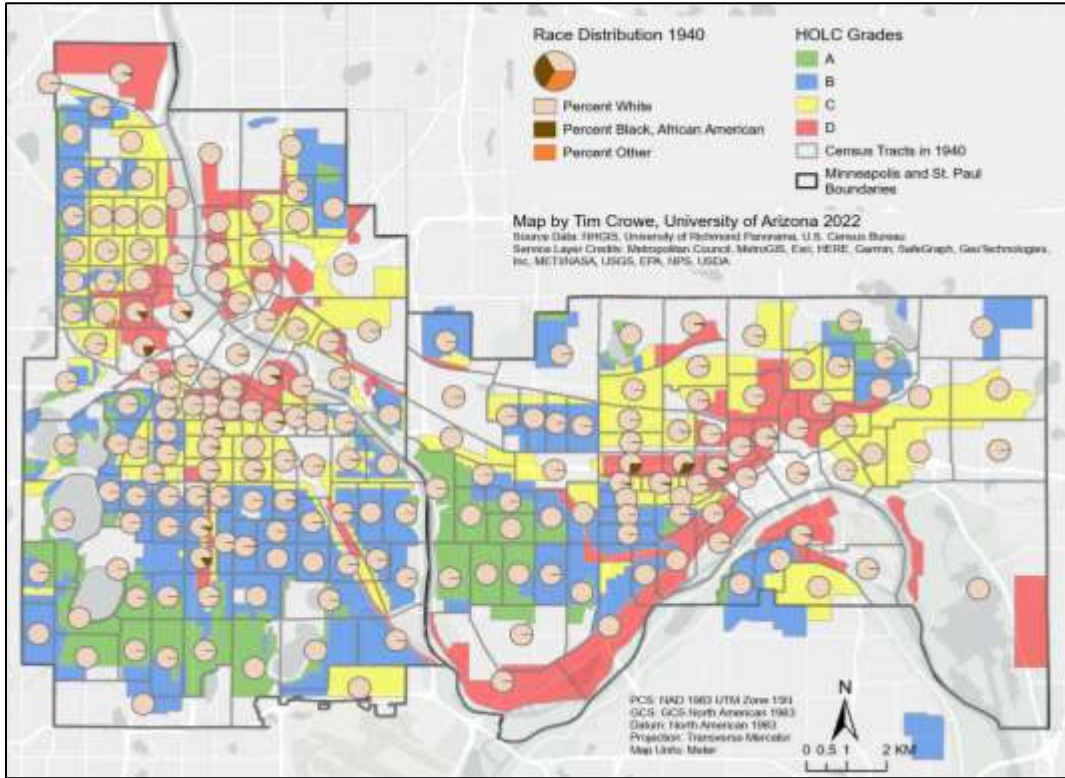


Figure 3-4. Racial distribution by 1940 census tracts

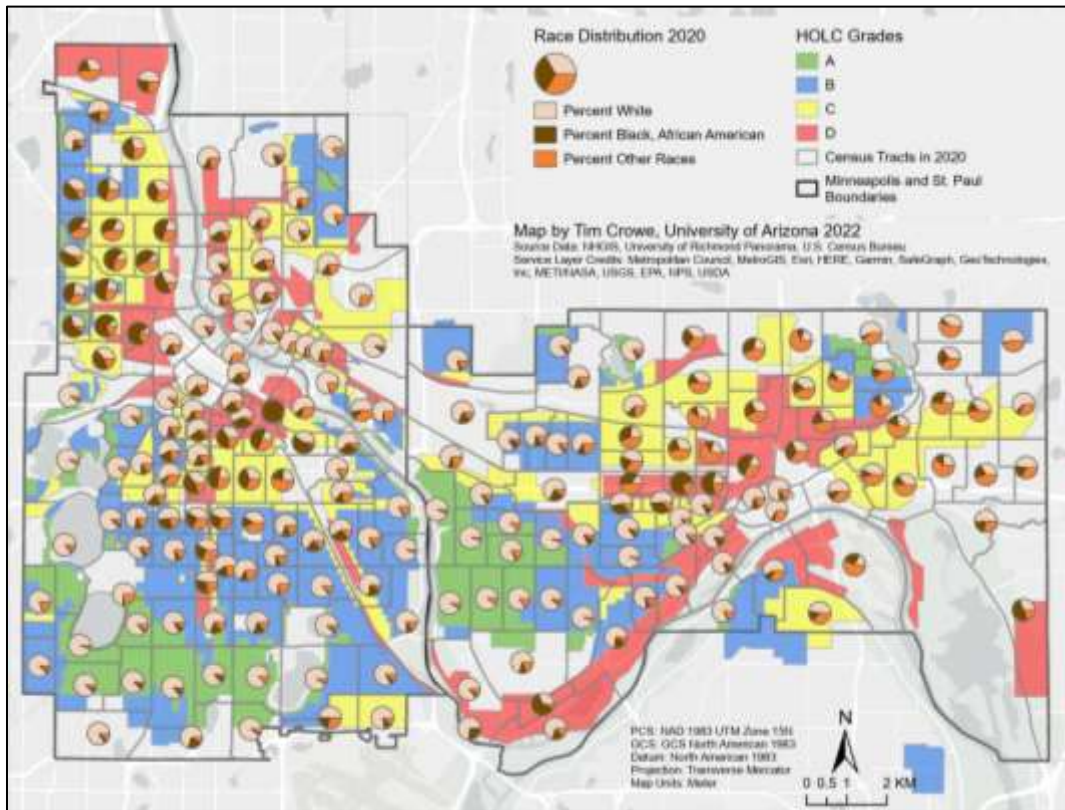


Figure 3-5. Racial distribution by 2020 census tract.

Housing tenure, owner vs renter occupied, was largely unchanged between 1940 and 2020 (Figure 3-6 and Figure 3-7). Red census tracts experienced the largest growth in owner occupied homes between 1940 and 2020. However, homeownership remained the lowest in red and yellow tracts during the same time frame. In 2020, the rate of owner-occupied homes in red and yellow districts is nearly the same: 36.4% and 37.6% respectively. In contrast, owner occupied homes in green areas is 74.5% in 2020.

Figures 3-8 and 3-9 show tenure by census tract for 1940 and 2020.

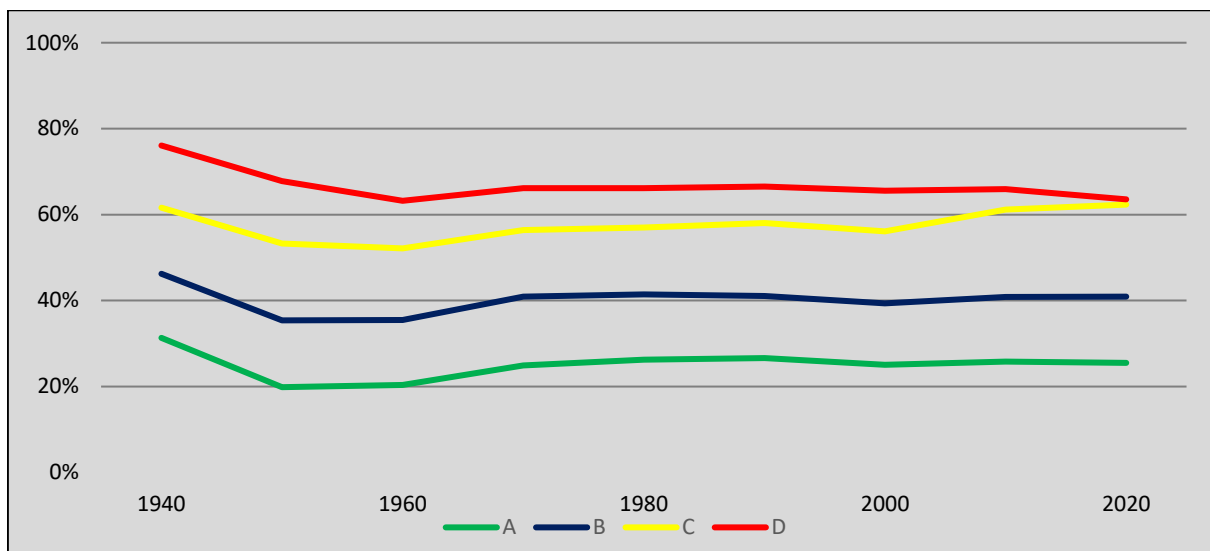


Figure 3-6. Percent Renter Occupied Housing by Year and Tract HOLC Grade

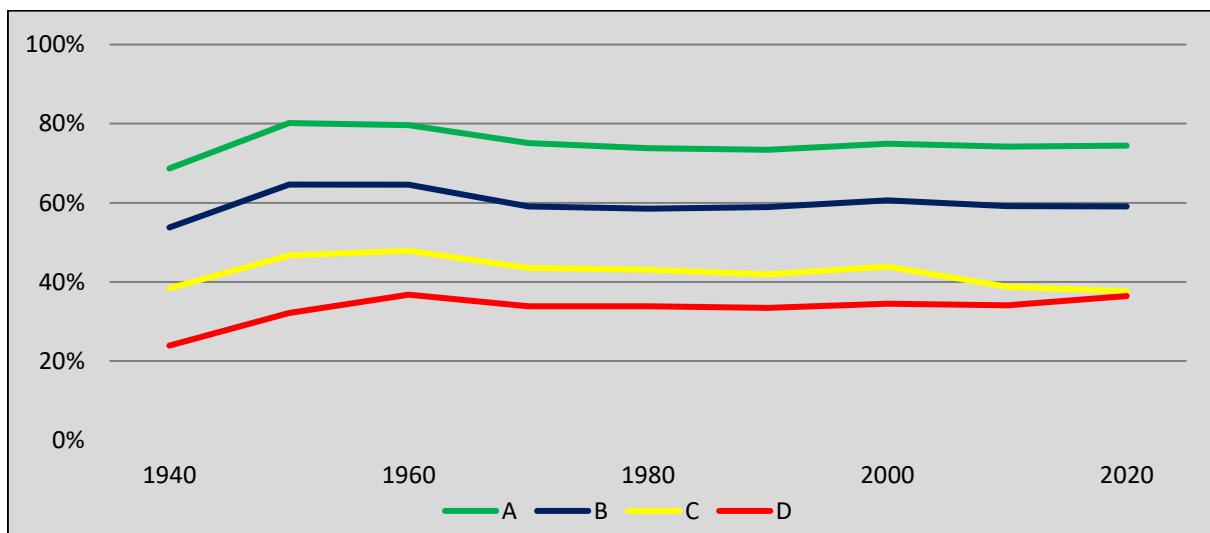


Figure 3-7. Percent Owner Occupied Housing by Year and Tract HOLC Grade

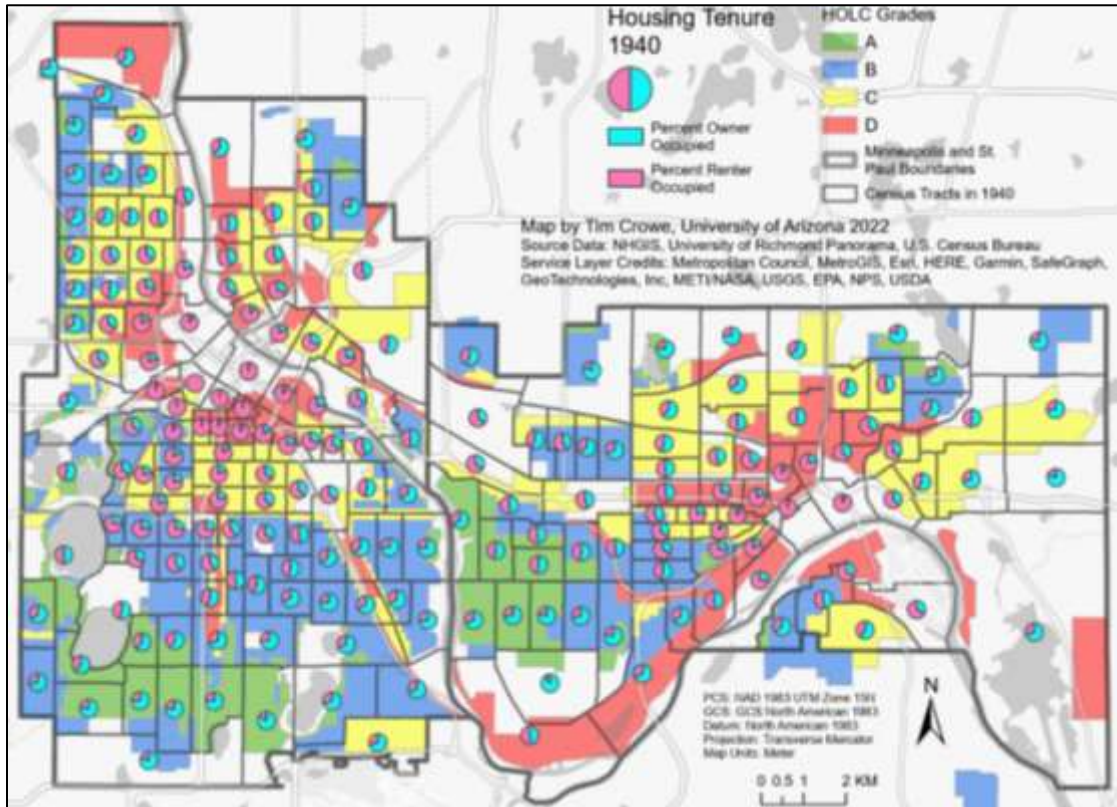


Figure 3-8. Housing tenure by 1940 census tract.

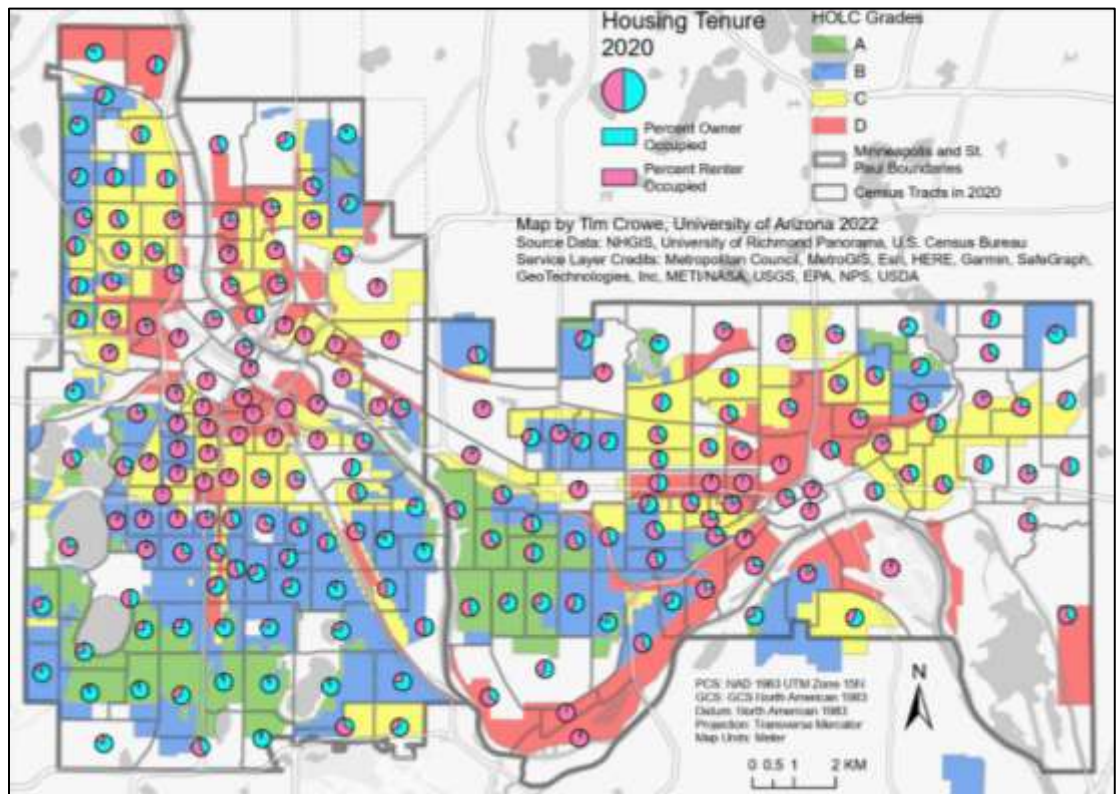


Figure 3-9. Housing tenure by 2020 census tract.

Inflation adjusted median home values increased in all tracts between 1940 and 2020 (Figure 3-10), although worse rated tracts remained well behind the better rated tracts. The largest growth occurred in top rated green tracts. Red tracts saw home values increase slightly more than yellow tracts by 2020. However, median home values in red, yellow and blue tracts continue to trail the green tracts. Median home values in these tracts are between 25% to 50% lower than green tracts. Figure 3-12 and 3-13 show median home values by census tract in 1940 and 2020.

However, the amount of area associated with an HOLC grade in each census tract showed little association with median home value as seen in scatter plots of each tract by HOLC grade area and median home value. As expected, based on the time series line charts, green and blue tended to have the highest median home values while red and yellow tended to have lower values. By 2020, this trend was less prevalent, with the scatter plots (Appendix D, Figures D-1 and D-2) showing significant dispersion for all tract grades in terms of median home value.

Between 1940 and 2020 time series line chart (Figure 3-11) show that the mean of median inflation adjusted gross rents increased a similar rate in all tracts. Rents in red tracts grew at rate approximately double yellow, blue and green tracts beginning with the 2000 Census.

Scatter plot comparison of inflation adjusted median gross rent (Appendix D, Figure D-5 and D-6) show varied association with HOLC graded area within a tract. Initially, these variables were positively associated but transitioned to a negative association. Lower graded tracts trended to lower gross rents, while higher graded

tracts clustered toward higher gross rents. By 2020 median gross rent is dispersed in HOLC grade and grade area.

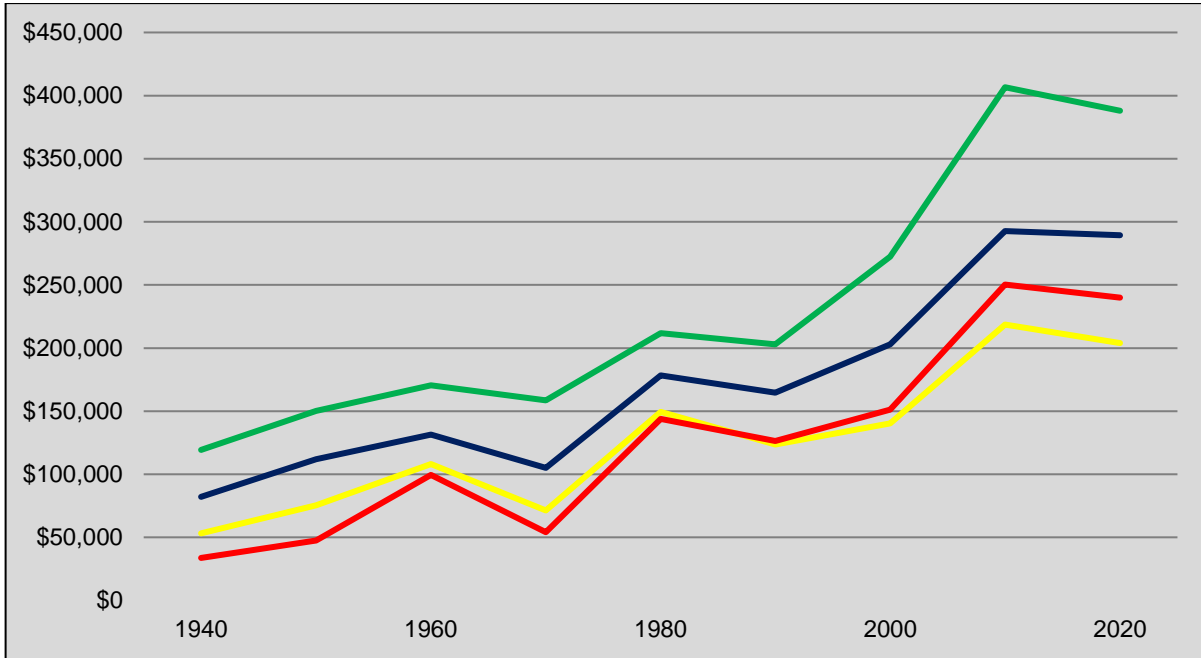


Figure 3-10. Mean of Median Home Values Inflation Adjusted (2020) U.S. Dollars by Year and Tract HOLC Grade

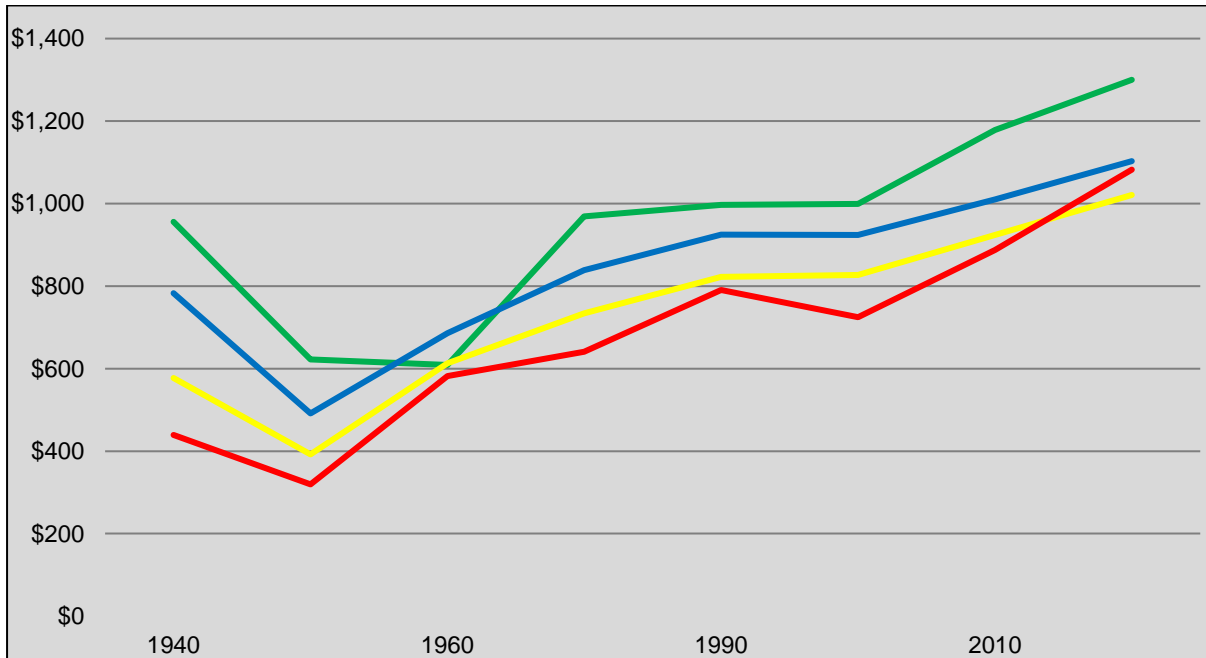


Figure 3-11. Mean of Median Rent Adjusted (2020) U.S. Dollars by Year and Tract HOLC Grade

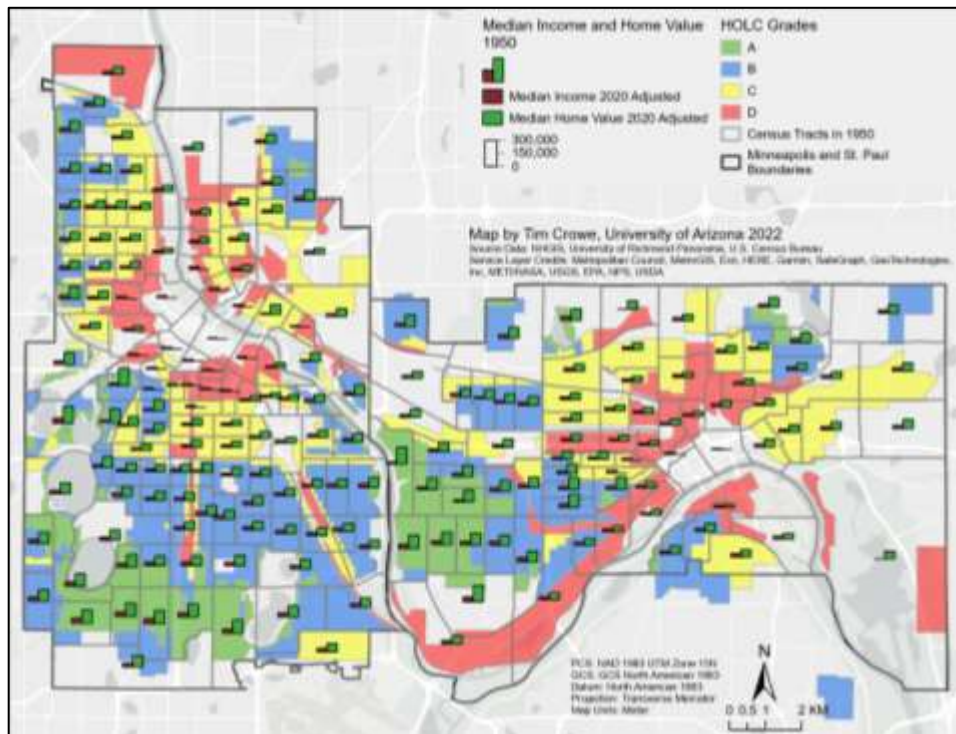


Figure 3-12. Median income and home values 1950 by census tract.

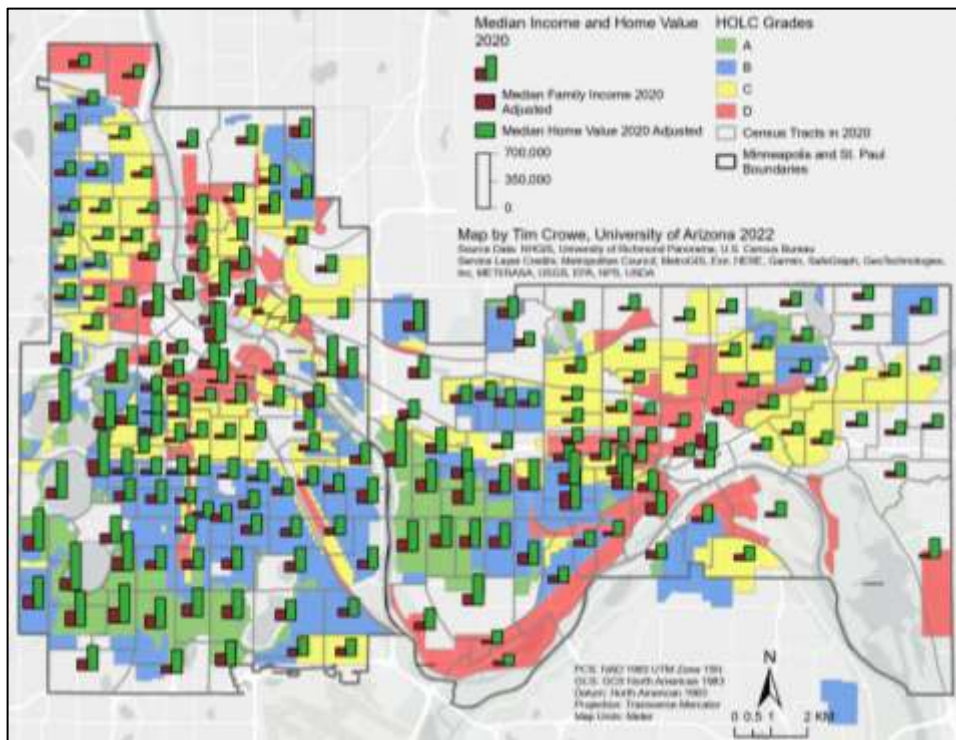


Figure 3-13. Median income and home values 2020 by census tract.



The mean of median inflation adjusted family incomes increased during the study timeframe. In 1950, tracts rated red saw incomes that were 60% less than incomes in the green tracts. In 2020, the red tracts maintained a similar gap with incomes at 58% of the green tracts. However, blue and especially yellow tracts saw their income gap widen when compared to green tracts. In 1950, yellow tracts median income was 73% of green tracts, falling to 45% in 2020.

Scatter plot comparison of inflation adjusted median family income and HOLC graded area (Appendix D, Figure D-3 and D-4) show very slight positive association with median income in 1950 (the first year for income data in the census data). Nonetheless, a tendency of red and yellow graded tracts to have lower median income was apparent in all years. Figures 3-12 and 3-13 show median income by census tract in 1940 and 2020.

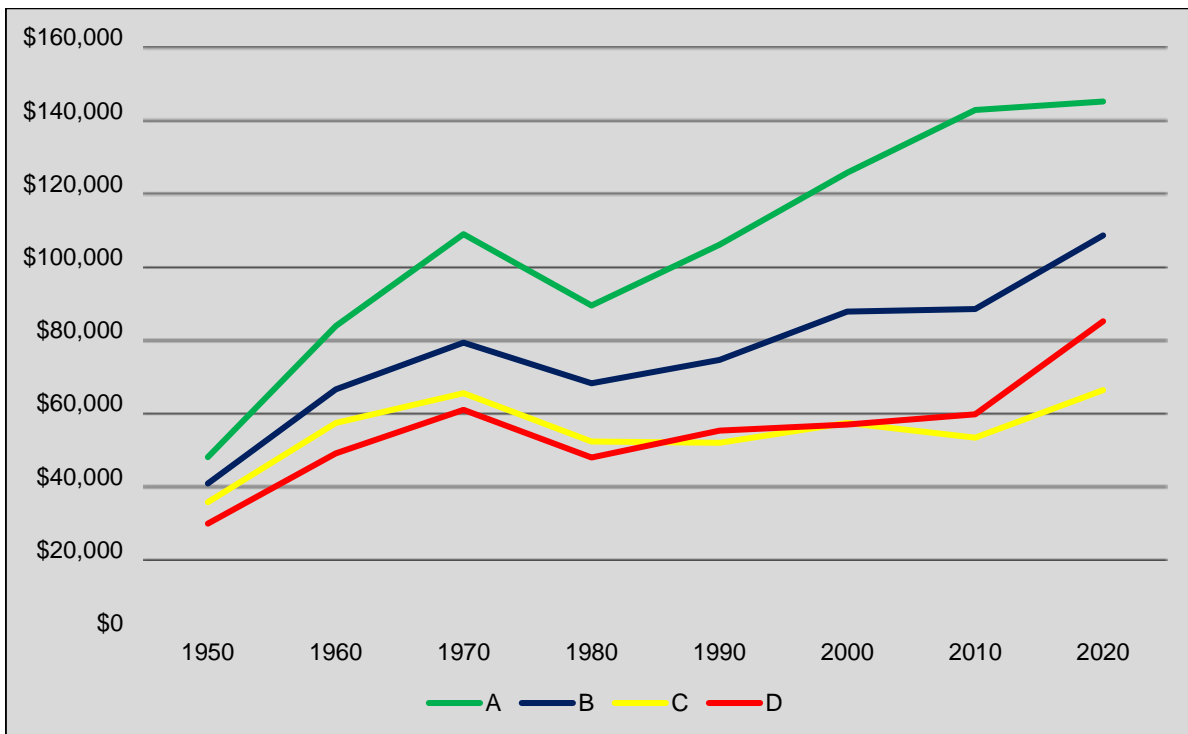


Figure 3-14. Mean of Median Family Income Inflation Adjusted (2020) by Year and Tract HOLC Grade

The overall unemployment rate in 1940 for red graded tracts was 18.7% while the rate was 5% in green tracts (Figure 3-15). Unemployment fell sharply between 1940 and 1950 as expected by war time employment. Unemployment began to rise from 1960 in red and yellow tracts and 1970 for blue tracts continuing to the 1990 census. All tracts saw a sharp rise in unemployment between the 2000 and 2010 census, likely associated with The Great Recession in 2008-2009. In 2020, the highest unemployment rate was yellow tracts at 6.4% with green tracts seen unemployment at 3.7%. However, the employment since 2020 data does appear to include effects from COVID-19 related closures and economic slowdowns later in 2020 and 2021. Figures 3-16 and 3-17 show unemployment by census tract for 1940 and 2020. Scatter plot comparison unemployment showed negative association the HOLC graded in early census years with a flat association in 2020 (Appendix D, Figures D-7 and D8).

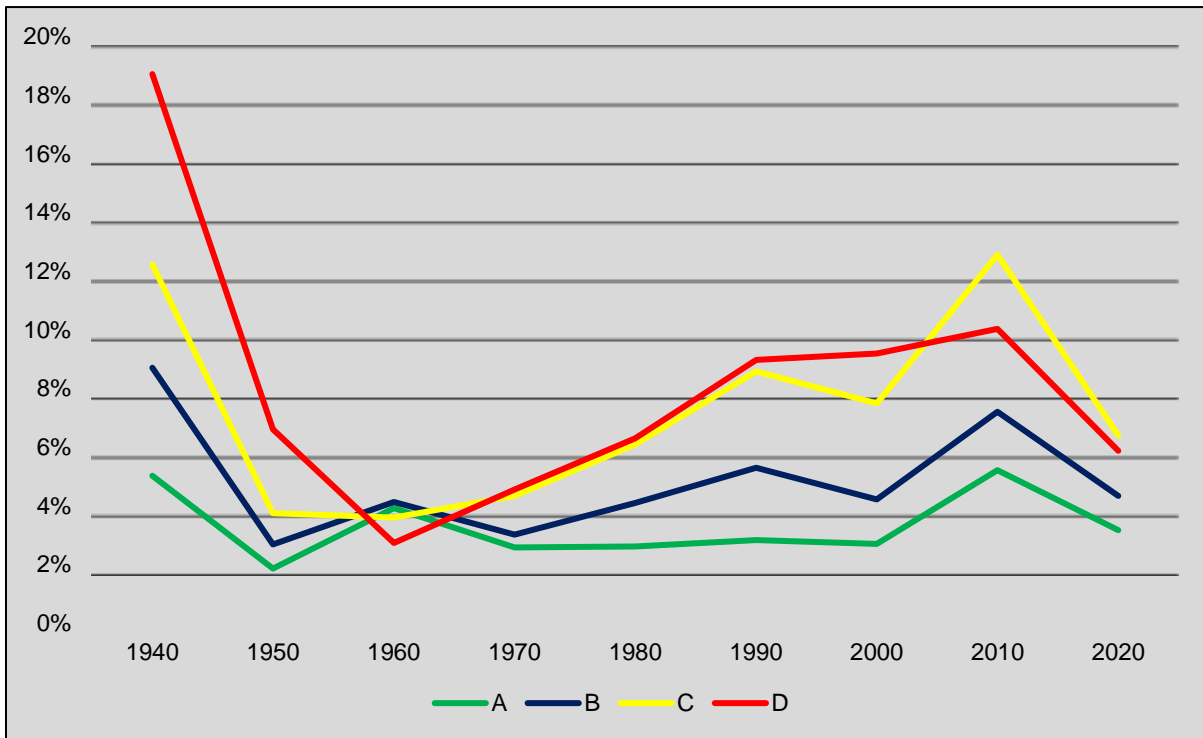


Figure 3-15. Unemployment Rate by Year and Tract HOLC Grade

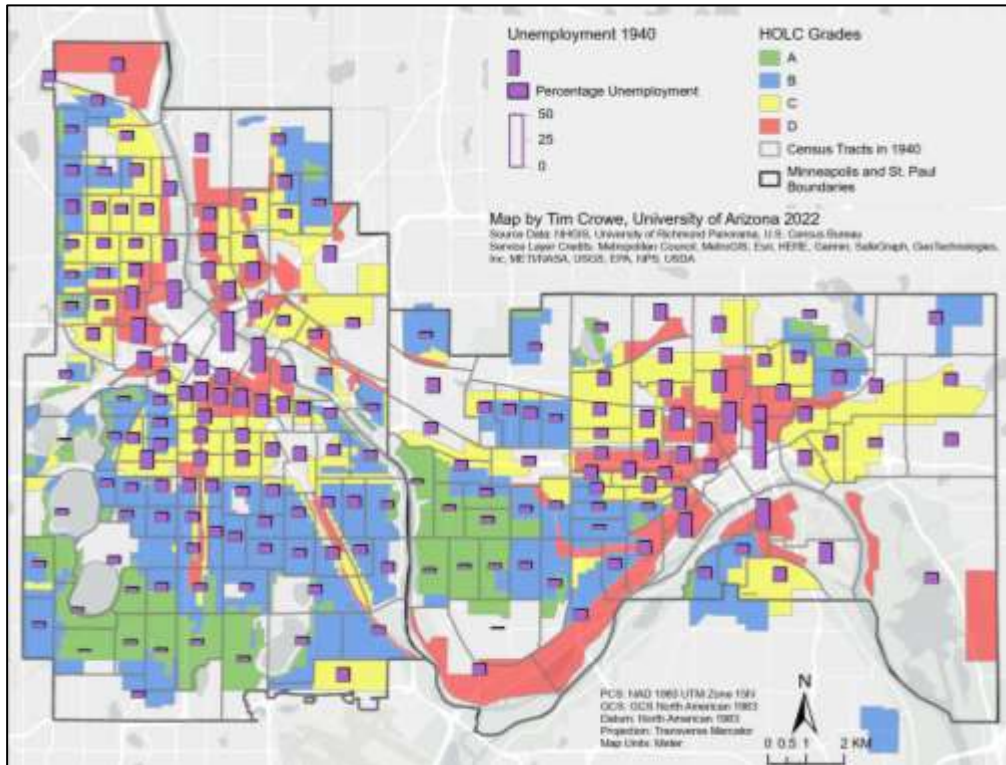


Figure 3-16. 1940 Unemployment by Census Tract

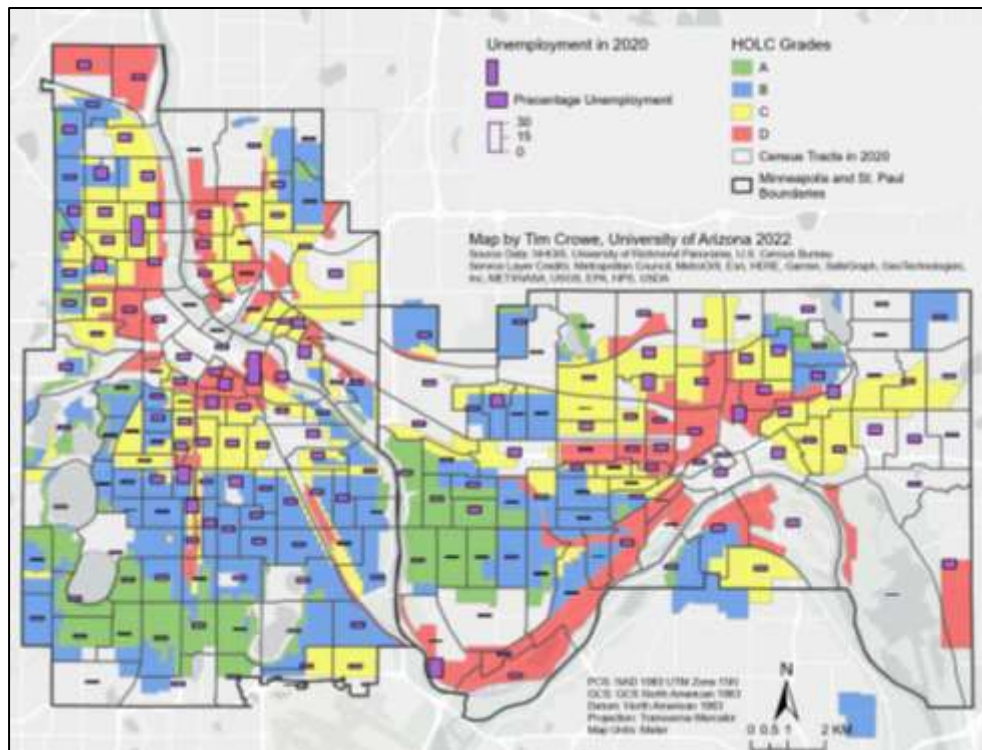


Figure 3-17. 2020 Unemployment by Census Tract

Regression analysis using median inflation adjusted house value as an independent variable in each census year yielded inconclusive results. For each census year, the Exploratory Regression tool was run. This tool conducts Ordinary Least Squares (OLS) regression against a list of user selected variables. The tool then helps the analyst identify the best fit model. In this case, all models failed various tests for fitness. Jarque-Bera and Koenker scores for most combinations of variables was near zero. This indicated missing variables and non-stationary residuals. This was anticipated given somewhat limited variety of variables consistently available from each census from 1940 to 2020. Also, Moran's I scores indicated significant spatial autocorrelation which was expected.

Given the highly spatially autocorrelated data, the Geographically Weighted Regression (GWR) tool was run. These regressions also yielded inconclusive results as models did not score well on fitness tests. Notwithstanding the above limitations, some independent variables were significant in multiple census years: median adjusted rent, median adjusted income, owner and renter occupied housing were frequently positively associated with median house value. HOLC grade was negatively associated with home values. However, its significance as an independent variable decreased substantially from 1980 to 2020. These independent variables are relevant and could contribute to future regression analysis using a more diverse set of variables. The regression results clearly show that a more complex set of variables is needed for a predictive model.

## CONCLUSION

This study did not set out to determine if HOLC redlining maps caused negative socioeconomic effects. Rather, the intent was to determine if negative effects existed in the Twin Cities, particularly in redlined areas, and to attempt to measure their change over time. To recap, this study's goals were:

1. Define consistent socioeconomic measures for each census year from 1940 to 2020.
2. Determine how these variables changed over time.
3. Compare changes in variables between best and worst graded areas.
4. Perform spatial regression analysis on selected measures.
5. Identify areas for potential future study.

Tract level measures selected for each census year were racial composition, housing tenure and median value, rental costs, unemployment and family income. Each tract was assigned the HOLC grade of which ever HOLC grade covered the most area in the tract. Time series charts show changes in socioeconomic measures across the study area aggregated by HOLC grade, while maps and scatter plots showed changes at the tract level. Lastly regression analysis was used to examine median house value in each census year.

The results of this study are mixed when considering what was expected based on research reviewed for this study. As anticipated, the Twin Cities saw large increases in Black Americans and other people of color in census tracts with majority yellow and red grades. Somewhat unexpectedly, red tracts maintained the same size gap in median income with green tracts, while yellow and blue tracts saw their gaps increase. Also not expected was the growth in median rents in red tracts at a rate double to other tracts. Home values in the worst rated tracts grew over time, however, they still lag well behind the green rated areas. Generally, the influence of HOLC grades lessened later

census years in scatter plots. Regression analysis of median home value using the selected data did not provide a reasonably predictive model. The influence of the HOLC grade in the regression models was less in later census data.

Over 80 years since the HOLC produced their residential security maps, the relative socioeconomic conditions between various graded areas had not changed much. Rather for some it has gotten worse. People living in the HOLC's worst rated areas earn less and live in houses of lesser value by margins similar to 1940 when compared to the best rated areas. The Twin Cities are also effectively more segregated than they were in 1940. Ultimately, redlining was a systemic racist practice that today results in endemic adverse spatially related socioeconomic conditions.

Lower property values mean lower property taxes that in turn means lower city service and school funding. Economic deprivation and segregation are linked to crime and social unrest. By way of example from a study of violent crime in Chicago found that "Over fifty-six years, racial and economic segregation have been closely tied to violence. High-poverty neighborhoods have consistently had murder rates that are three to five times as high as lower-poverty neighborhoods" (Sharkey & Marsteller, 2022). This same study found similar patterns in the 100 most populous cities in United States. Legislators should use this type of information to make spatially informed resourcing decisions to combat socioeconomic disparities and other associated problems. This would potentially allow inequality to be addressed.

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## Appendix A – Census Data Sets

### 1940 Census Data Sets

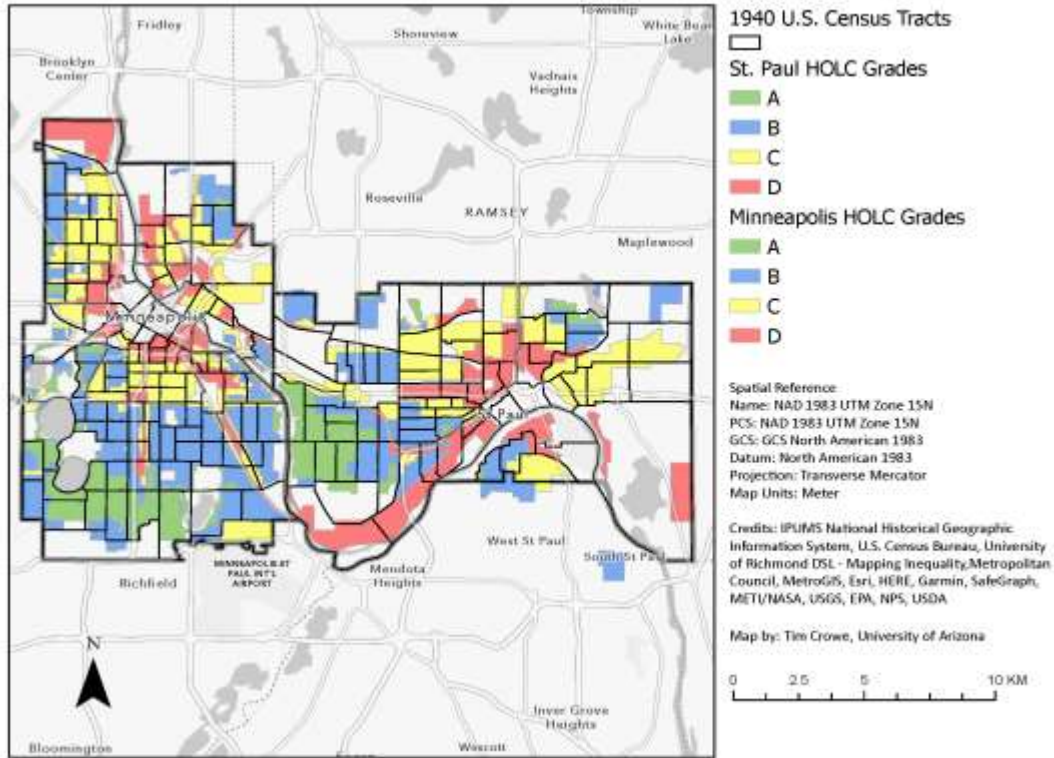


Figure A-1. Map of 1940 Census Tracts and HOLC Grades

Table A-1. 1940 Census Table and Tract Files

Official Name of Data Set	1940 Census: Population & Housing Data [Tracts & NY Health Areas: Major Cities & Surrounds]
Year of Publication	2022 (Version 17.0)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Census data by tract; Requires joining to tract boundary shape file.
Official Name of Data Set	Historic US Census Tract Boundaries, 1940
Year of Publication	2004 (Version 1)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Shapefile of U.S. Census Tracts in 1940
Coordinate System	NAD 1983 (GRS 1980, North American Datum of 1983, EPSG:4269)
Projection System	USA Contiguous Albers Equal Area Conic
Type of Geometry	Polygon

## 1950 Census Data Sets

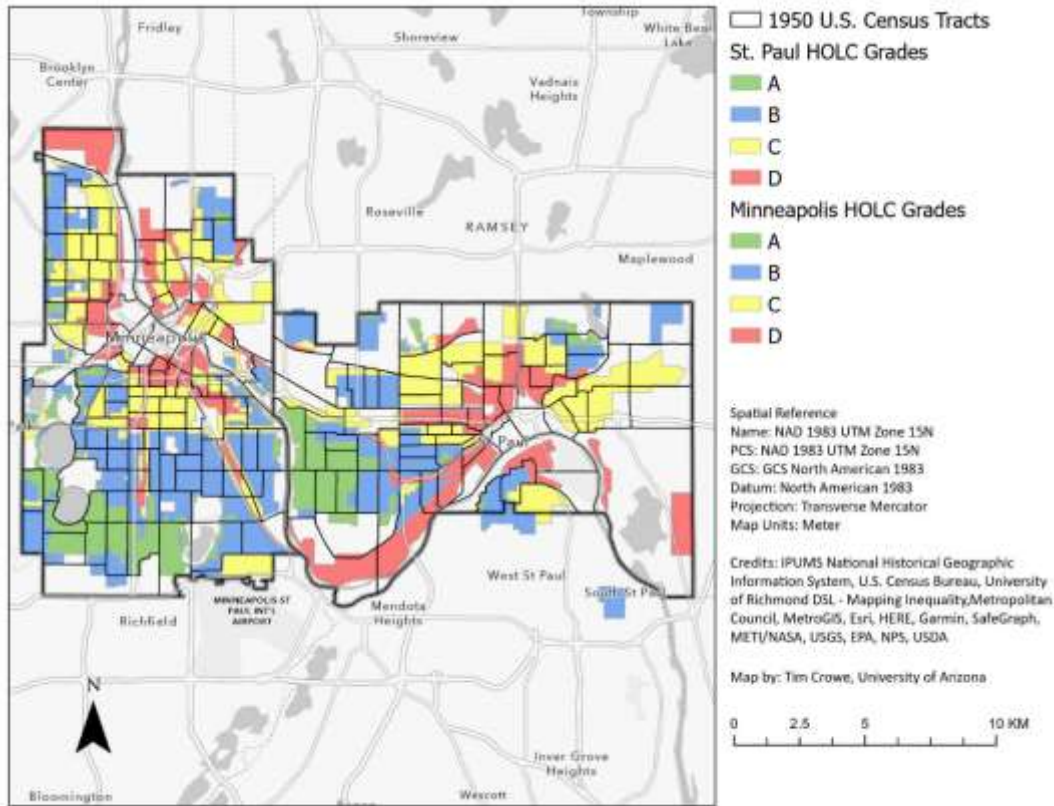


Figure A-2. Map of 1950 Census Tracts and HOLC Grades

Table A-2. 1950 Census Table and Tract Files

Official Name of Data Set	1950 Census: Population & Housing Data [Tracts: Major Cities & Surrounds]
Year of Publication	2022 (Version 17.0)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Census data by tract; Requires joining to tract boundary shape file.
Official Name of Data Set	Historic US Census Tract Boundaries, 1950
Year of Publication	2004 (Version 1)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Shapefile of U.S. Census Tracts in 1950
Coordinate System	NAD 1983 (GRS 1980, North American Datum of 1983, EPSG:4269)
Projection System	USA Contiguous Albers Equal Area Conic
Type of Geometry	Polygon

## 1960 Census Data Sets

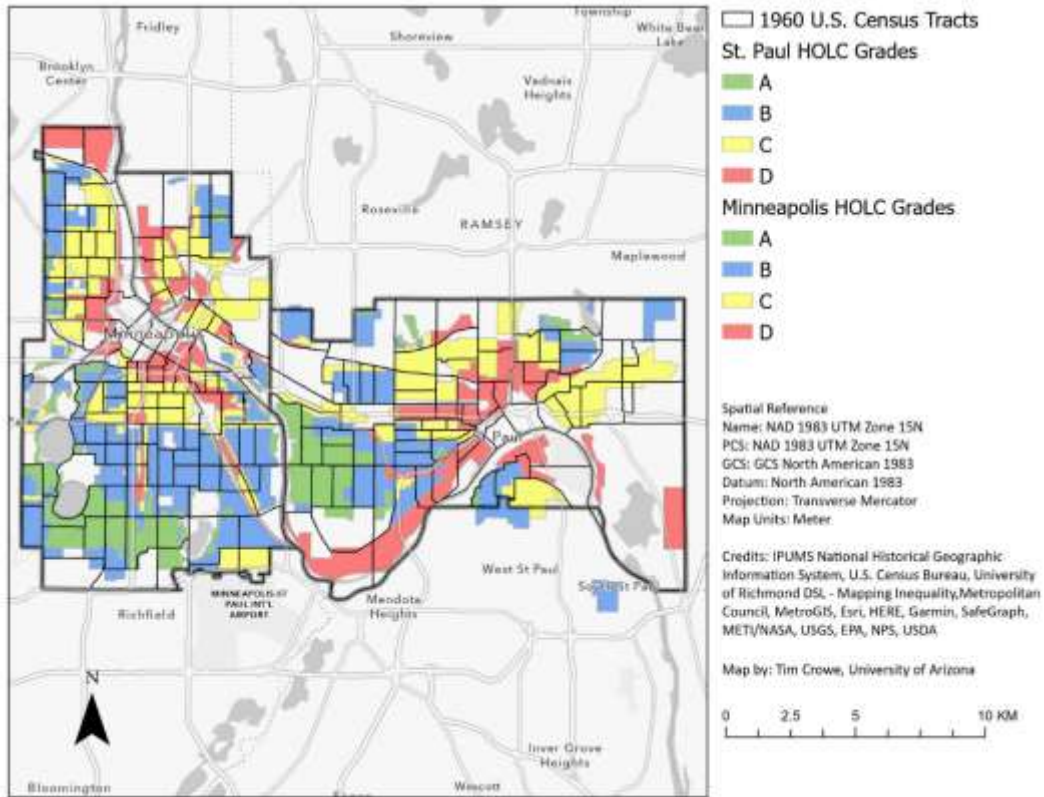


Figure A-3. Map of 1960 Census Tracts and HOLC Grades

Table A-3. 1960 Census Table and Tract Files

Official Name of Data Set	1960 Census: Population & Housing Data [Tracts: Major Cities & Surrounds]
Year of Publication	2022 (Version 17.0)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Census data by tract; Requires joining to tract boundary shape file.
Official Name of Data Set	Historic US Census Tract Boundaries, 1960
Year of Publication	2004 (Version 1)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Shapefile of U.S. Census Tracts in 1960
Coordinate System	NAD 1983 (GRS 1980, North American Datum of 1983, EPSG:4269)
Projection System	USA Contiguous Albers Equal Area Conic
Type of Geometry	Polygon

## 1970 Census Data Sets

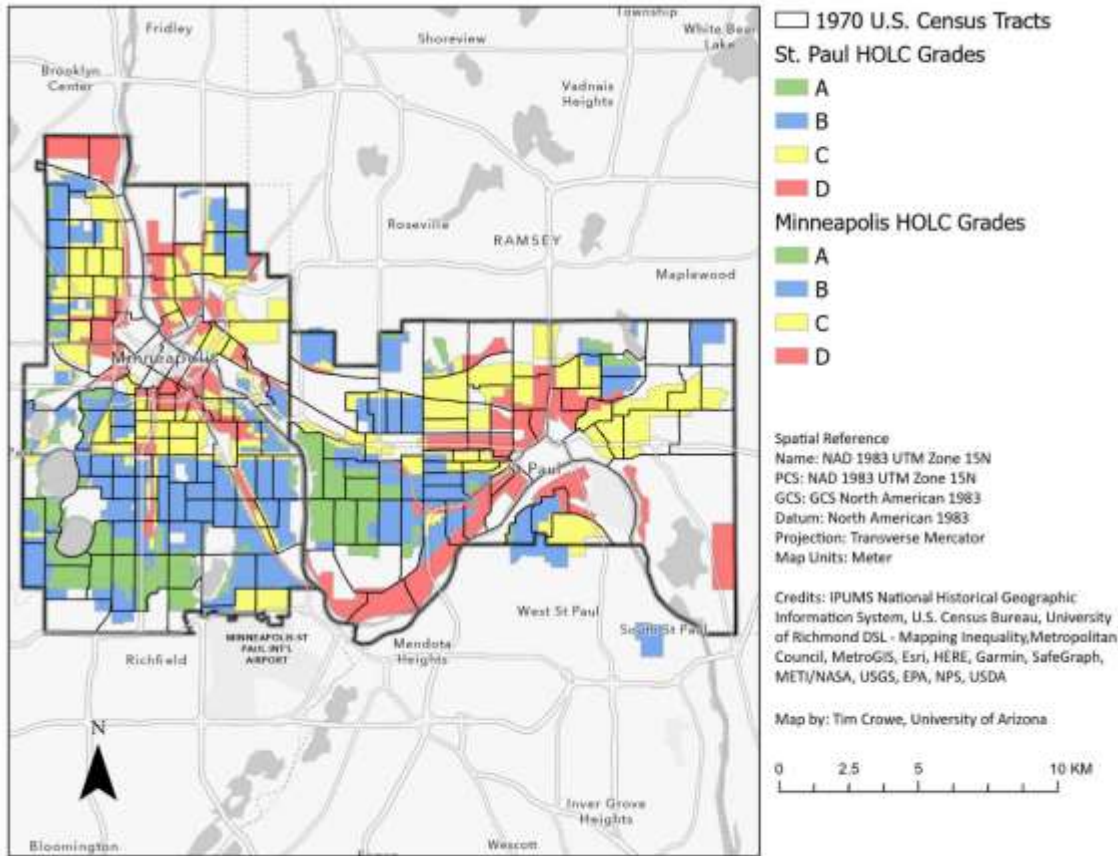


Figure A-4. Map of 1970 Census Tracts and HOLC Grades

Table A-4. 1970 Census Table and Tract Files

Official Name of Data Set	1970 Census: Count 2 - 100% Data [Tracts, Urban Areas, Metro Areas, etc.]
Year of Publication	2022 (Version 17.0)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Census data by tract. Does not contain geospatial information.
Official Name of Data Set	Historic US Census Tract Boundaries, 1970
Year of Publication	2004 (Version 1)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Shapefile of U.S. Census Tracts in 1960
Coordinate System	NAD 1983 (GRS 1980, North American Datum of 1983, EPSG:4269)
Projection System	USA Contiguous Albers Equal Area Conic
Type of Geometry	Polygon

## 1980 Census Data Sets

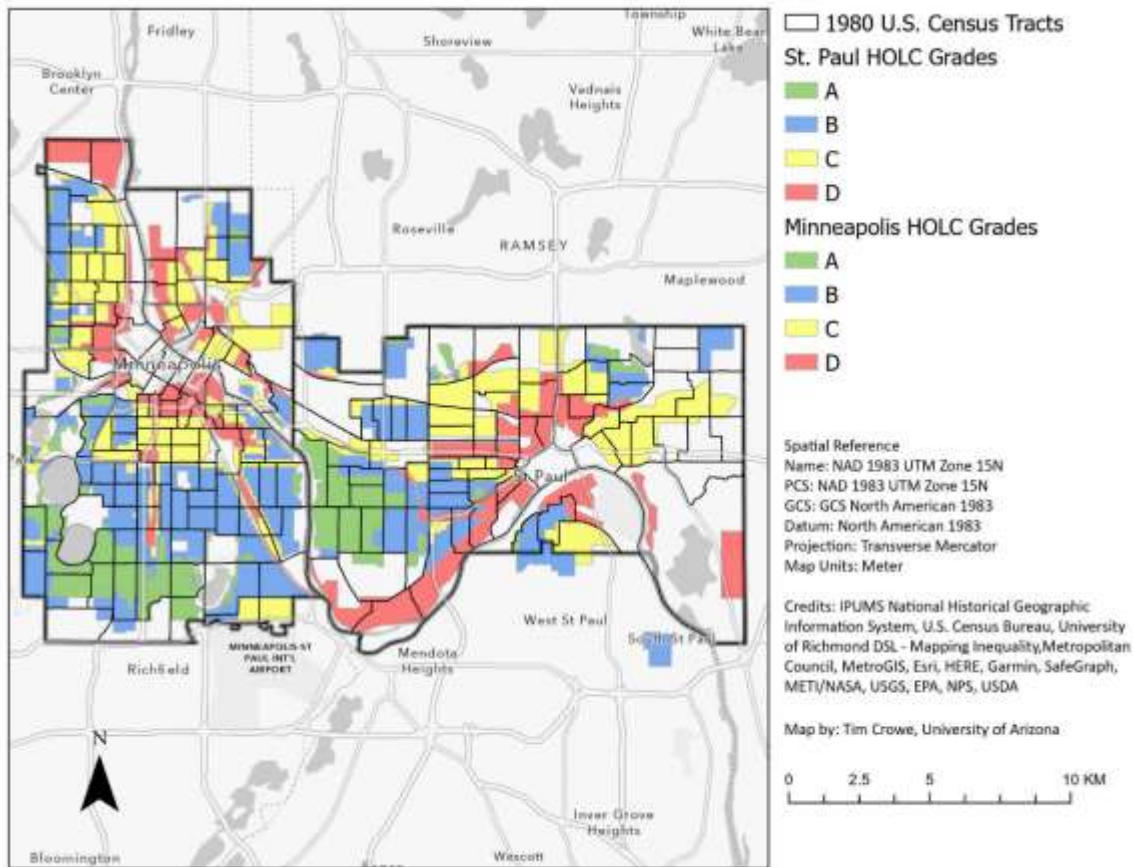


Figure A-5. Map of 1980 Census Tracts and HOLC Grades

Table A-5. 1980 Census Table and Tract Files

Official Name of Data Set	1980 Census: STF 1 - 100% Data
Year of Publication	2022 (Version 17.0)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Census data by tract. Does not contain geospatial information.
Official Name of Data Set	Historic US Census Tract Boundaries, 1980
Year of Publication	2004 (Version 1)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Shapefile of U.S. Census Tracts in 1980
Coordinate System	NAD 1983 (GRS 1980, North American Datum of 1983, EPSG:4269)
Projection System	USA Contiguous Albers Equal Area Conic
Type of Geometry	Polygon

## 1990 Census Data Sets

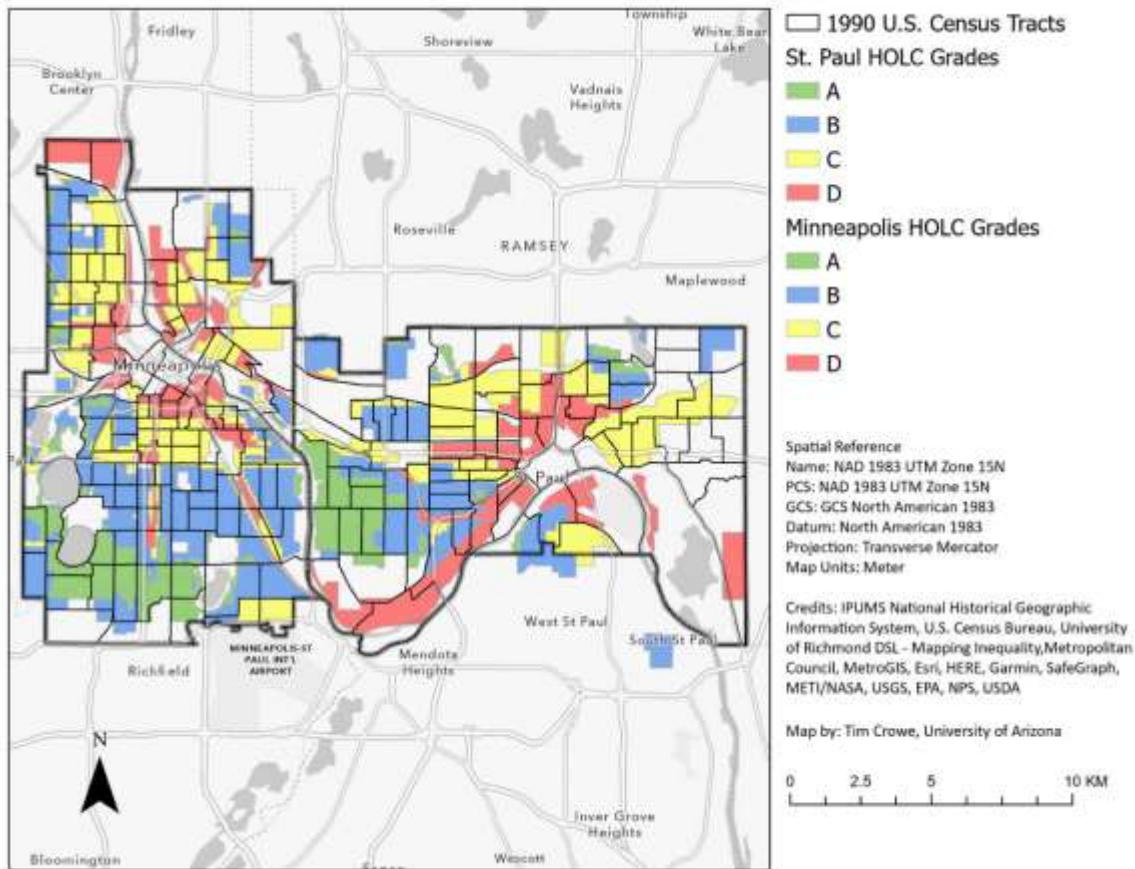


Figure A-6. Map of 1990 Census Tracts and HOLC Grades

Table A-6. 1990 Census Table and Tract Files

Official Name of Data Set	1990 Census: STF 1 - 100% Data
Year of Publication	2022 (Version 17.0)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Census data by tract. Does not contain geospatial information.
Official Name of Data Set	Historic US Census Tract Boundaries, 1990
Year of Publication	2004 (Version 1)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Shapefile of U.S. Census Tracts in 1990
Coordinate System	NAD 1983 (GRS 1980, North American Datum of 1983, EPSG:4269)
Projection System	USA Contiguous Albers Equal Area Conic
Type of Geometry	Polygon

## 2000 Census Data Sets

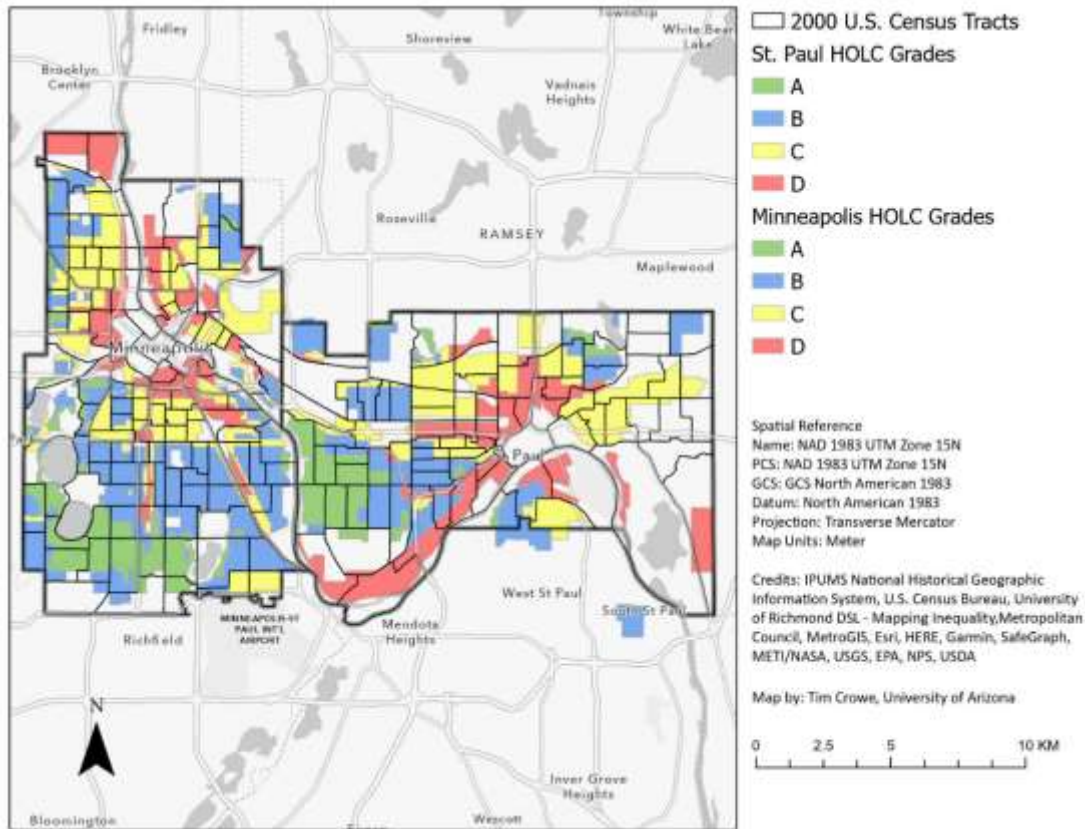


Figure A-7. Map of 2000 Census Tracts and HOLC Grades

Table A-7. 2000 Census Table and Tract Files

Official Name of Data Set	2000 Census: SF 1a - 100% Data [Areas Larger Than Block Groups]
Year of Publication	2022 (Version 17.0)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Census data by tract.
Official Name of Data Set	None – data set is to be joined with associated shapefile

Official Name of Data Set	Historic US Census Tract Boundaries, 2000
Year of Publication	2004 (Version 1)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Shapefile of U.S. Census Tracts in 2000
Coordinate System	NAD 1983 (GRS 1980, North American Datum of 1983, EPSG:4269)
Projection System	USA Contiguous Albers Equal Area Conic
Type of Geometry	Polygon

## 2010 Census Data Sets

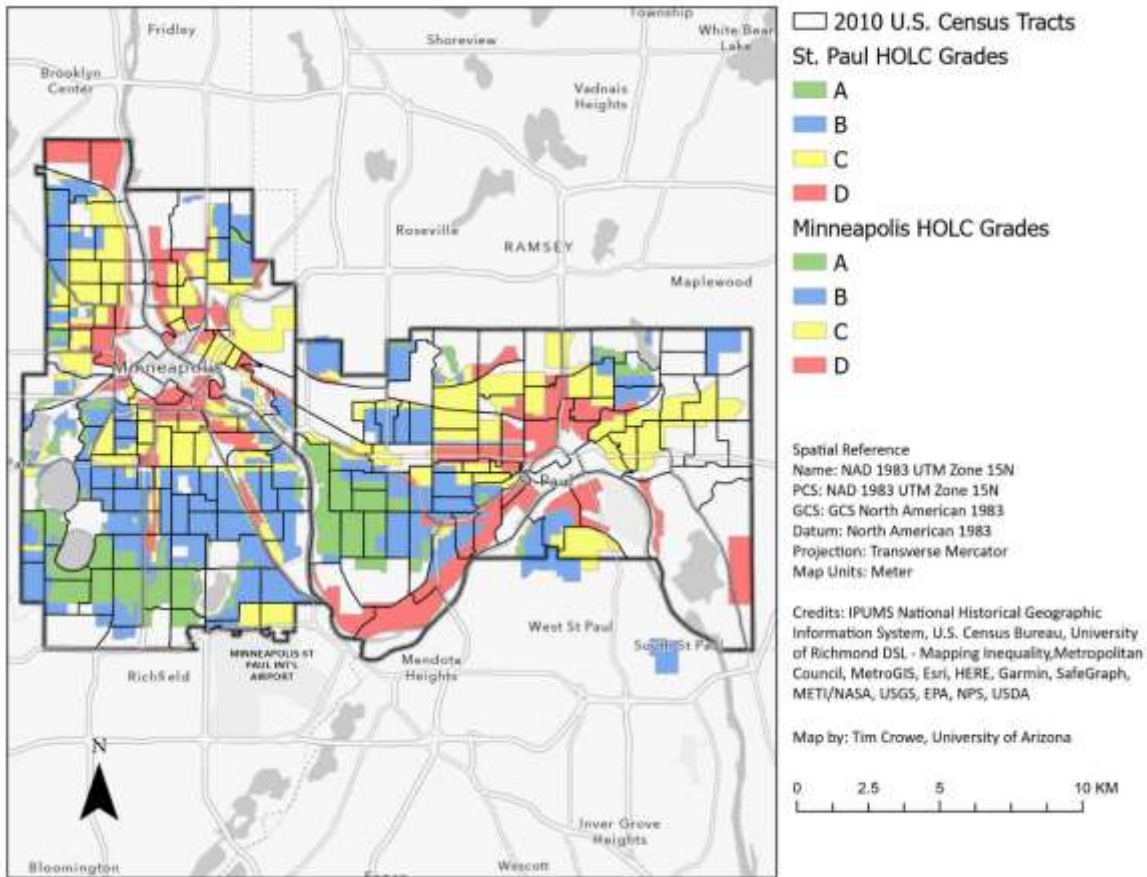


Figure A-8. Map of 2010 Census Tracts and HOLC Grades

Table A-8. 2010 Census Table and Tract Files

Official Name of Data Set	2010 Census: SF 1a - P & H Tables [Blocks & Larger Areas]
Year of Publication	2022 (Version 17.0)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Census data by tract. Does not contain geospatial information.
Official Name of Data Set	NHGIS: TIGER/Line Shapefile, 2010
Year of Publication	2004 (Version 1)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Shapefile of U.S. Census Tracts in 2010
Coordinate System	NAD 1983 (GRS 1980, North American Datum of 1983, EPSG:4269)
Projection System	USA Contiguous Albers Equal Area Conic
Type of Geometry	Polygon



## 2020 American Community Survey Data Sets

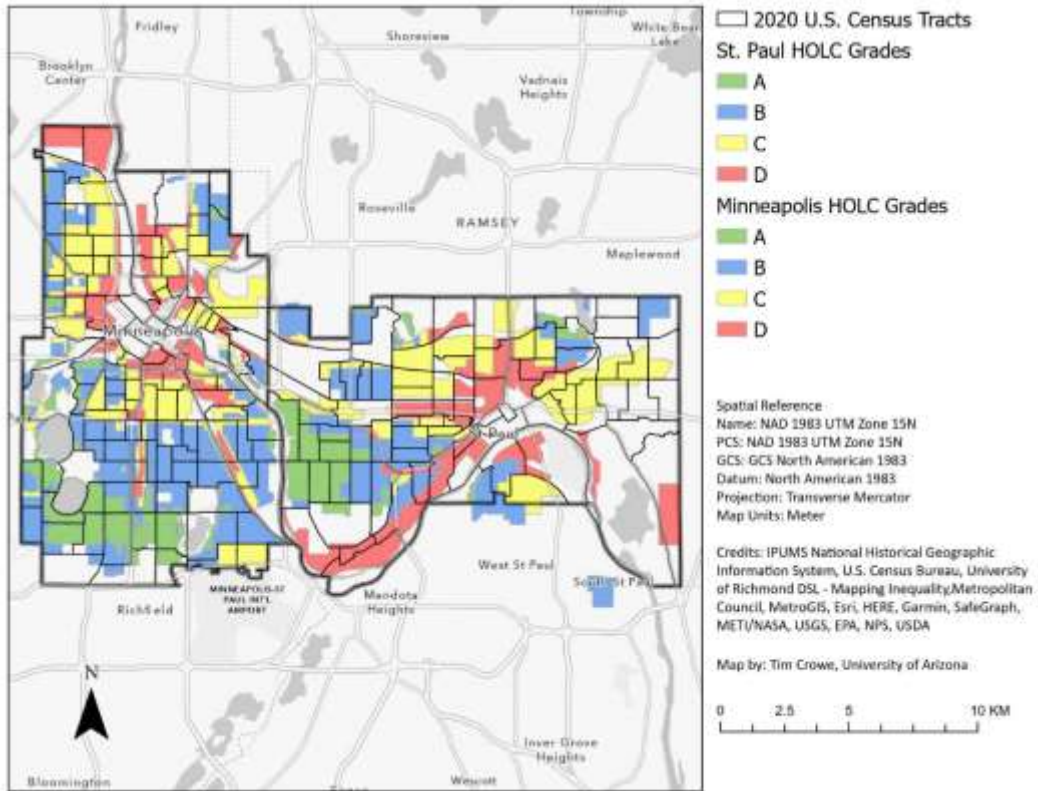


Figure A-9. Map of 2020 Census Tracts and HOLC Grades

Table A-9. 2020 Census Table and Tract Files

Official Name of Data Set	2020 American Community Survey: 5-Year Data [2016-2020, Block Groups & Larger Areas]
Year of Publication	2022 (Version 17.0)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Census data by tract. Does not contain geospatial information.
Official Name of Data Set	NHGIS 2020 Census Tract Boundary File: United States and Puerto Rico
Year of Publication	2021 (Version 1)
Author and/or Owner	IPUMS National Historical Geographic Information System
Original Creator	U.S. Census Bureau
URL or FTP address	<a href="http://doi.org/10.18128/D050.V17.0">http://doi.org/10.18128/D050.V17.0</a>
Description	Shapefile of U.S. Census Tracts in 2020
Coordinate System	NAD 1983 (GRS 1980, North American Datum of 1983, EPSG:4269)
Projection System	USA Contiguous Albers Equal Area Conic
Type of Geometry	Polygon

## Appendix B – Regression Results for Median Home Value

**Table B-1. 1940 Median Home Value 2020 Inflation Adjusted Regression Results**

Geographically Weighted Regression:			
Number of Features	196		
Dependent Variable	BVC001C	Median Home Value 2020 Adjusted	
Explanatory Variables	BUQ001	White Population	
	BUQ002	Other Races	
	BVG001	Black Population	
	BU2001	Owner Occupied	
	BU2002	Renter Occupied	
	BVJ001C	Median Gross Rent 2020 Adjusted	
	BUHCALC6	High School Graduate	
	BUHCALC8	College Graduate	
	BUX003	Male >> In labor force: Seeking work	
	BUX011	Female >> In labor force: Seeking work	
	MIN_GRADE	HOLC Minimum Grade	
	Number of Neighbors	77	
	Model Diagnostics		
R2	0.9118		
AdjR2	0.8658		
AICc	4313.2511		
Sigma-Squared	145223951.3		
Sigma-Squared MLE	95722680.68		
Effective Degrees of Freedom	129.1911		
Adjusted Critical Value of Pseudo-t Statistics	2.5656		

**Best OLS Model fit from Exploratory Regression:**

AdjR2	AICc	JB	K(BP)	VIF	SA	Model
0.74	4375.8	0	0	2.37	0	-BU2002** +BUHCALC8*** -BUX003*** -MAJ_GRADE***

**Table B-2. 1950 Median Home Value 2020 Inflation Adjusted Regression Results**

Geographically Weighted Regression:		
Number of Features	195	
Dependent Variable	B09CALC	Median Home Value 2020 Adjusted
Explanatory Variables	B0J003	Other Races
	B0B009	College: 4 years or more
	B0P002	Male >> Unemployed
	B0P004	Female >> Unemployed
	MAJ_GRADE	HOLC Grade
	Number of Neighbors	194
R2	0.7438	
AdjR2	0.7282	
AICc	4470.9595	
Sigma-Squared	503981232.5	
Sigma-Squared MLE	475167446.5	
Effective Degrees of Freedom	183.8514	
Adjusted Critical Value of Pseudo-t Statistics	2.1521	

**Best OLS Model fit from Exploratory Regression:**

AdjR2	AICc	JB	K(BP)	VIF	SA	Model
0.73	4466.6	0	0	2.56	0.26	-B0J003*** +B0B009*** -B0P002** -B0P004*** -MAJ_GRADE

**Table B-3. 1960 Median Home Value 2020 Inflation Adjusted Regression Results**

Geographically Weighted Regression:		
Number of Features	200	
Dependent Variable	B7OMEDC	Median Home Value 2020 Adjusted
Explanatory Variables	B7PMEDC	Median gross monthly rent 2020 adjusted
	BSDMEDC	Median family income 2020 adjusted
	B96001	Home Built: 1950-1960
	MAJ_GRADE	HOLC Grade
Number of Neighbors	199	
R2	0.224	
AdjR2	0.1788	
AICc	5024.2891	
Sigma-Squared	4538194058	
Sigma-Squared MLE	4289568452	
Effective Degrees of Freedom	189.043	
Adjusted Critical Value of Pseudo-t Statistics	2.2098	

Best OLS Model fit from Exploratory Regression:

AdjR2	AICc	JB	K(BP)	VIF	SA	Model
0.19	5020.43	0	0.31	1.95	0.99	+B7PMEDC +BSDMEDC*** +B96001 +MAJ_GRADE

**Table B-4. 1970 Average Home Value 2020 Inflation Adjusted Regression Results**

Geographically Weighted Regression:		
Number of Features	200	
Dependent Variable	CS5CALC2	Average Home Value 2020 Adjusted
Explanatory Variables	CK2002	Renter-Occupied
	CYXCALC2	Average Gross Rent adj 2020
	C1KCALC2	Average Family Income adj 2020
	POP_WHITE	White Population
	POP_BLACK	Black Population
Number of Neighbors	69	
R2	0.9223	
AdjR2	0.9003	
AICc	4444.3117	
Sigma-Squared	217765722.5	
Sigma-Squared MLE	170004296	
Effective Degrees of Freedom	156.135	
Adjusted Critical Value of Pseudo-t Statistics	2.6487	

Best OLS Model fit from Exploratory Regression:

AdjR2	AICc	JB	K(BP)	VIF	SA	Model
0.88	4461.29	0	0	2.25	0	-CK2002*** +CYXCALC2*** +C1KCALC2*** +POP_WHITE*** +POP_BLACK***

NOTE: The census data provided by NHGIS did not list median home value as in other census years. Only average home value was available.

**Table B-5. 1980 Median Home Value 2020 Inflation Adjusted Regression Results**

Geographically Weighted Regression:		
Number of Features	203	
Dependent Variable	C8JCALC	Median Home Value 2020 Adjusted
Explanatory Variables	C7W002	Renter occupied
	DILCALC	Median family income 2020 adjusted
	DHM003	High school: 4 years
	DEQ001	Home Built 1979-March 1980
	DEQ006	Home Built 1940-1949
	Number of Neighbors	141
R2	0.6212	
AdjR2	0.5769	
AICc	4925.5988	
Sigma-Squared	1851917717	
Sigma-Squared MLE	1658885372	
Effective Degrees of Freedom	181.8405	
Adjusted Critical Value of Pseudo-t Statistics	2.3946	

Best OLS Model fit from Exploratory Regression:

AdjR2	AICc	JB	K(BP)	VIF	SA	Model
0.52	5357	0	0.02	2.19	0.81	+C7W002*** +DILCALC*** -DHM003*** +DEQ001*** +DEQ006**

**Table B-6. 1990 Median Home Value 2020 Inflation Adjusted Regression Results**

Geographically Weighted Regression:		
Number of Features	204	
Dependent Variable	ESTCALC	Median Home Value 2020 Adjusted
Explanatory Variables	ES1002	Renter-Occupied
	E33003	High School Grad
	E0RCALC	Median Family Income 2020
	MAJ_GRADE	HOLC Grade
	Number of Neighbors	41
R2	0.8204	
AdjR2	0.7308	
AICc	4911.7783	
Sigma-Squared	1219690606	
Effective Degrees of Freedom	136.4661	
Adjusted Critical Value of Pseudo-t Statistics	2.8556	

Best OLS Model fit from Exploratory Regression:

AdjR2	AICc	JB	K(BP)	VIF	SA	Model
0.55	4992.9	0	0	1.36	0	+ES1002*** -E33003*** +E0RCALC*** -MAJ_GRADE**

**Table B-7. 2000 Median Home Value 2020 Inflation Adjusted Regression Results**

Geographically Weighted Regression:		
Number of Features	198	
Dependent Variable	GB7CALC	Median Home Value 2020 Adjusted
Explanatory Variables	FKN002	Renter occupied
	GMYCLAC	Median Household Income 2020 Adjusted
	GKTCALC9	High School Graduate
Number of Neighbors	197	
R2	0.518	
AdjR2	0.4964	
AICc	5011.1309	
Sigma-Squared	5520068240	
Sigma-Squared MLE	5285143759	
Effective Degrees of Freedom	189.5735	
Adjusted Critical Value of Pseudo-t Statistics	2.1952	

**Best OLS Model fit from Exploratory Regression:**

AdjR2	AICc	JB	K(BP)	VIF	SA	Model
0.59	4969.4	0	0.23	1.06	0.09	+ES1002*** -E33003*** +E0RCALC*** -MAJ_GRADE**

**Table B-8. 2010 Median Home Value 2020 Inflation Adjusted Regression Results**

Geographically Weighted Regression:		
Number of Features	194	
Dependent Variable	JTIECALC	Median Home Value 2020 Adjusted
Explanatory Variables	H7X002	White Population
	IFP002	Owner-Occupied
	JN9ECALC9	High School Graduate
	JPOECALC	Median Family Income 2020 Adjusted
Number of Neighbors	54	
R2	0.8735	
AdjR2	0.8312	
AICc	4717.3185	
Sigma-Squared	1720023043	
Sigma-Squared MLE	1291375886	
Effective Degrees of Freedom	145.6532	

**Best OLS Model fit from Exploratory Regression:**

AdjR2	AICc	JB	K(BP)	VIF	SA	Model
0.76	4757.4	0	0	3.37	0.01	+H7X002*** -IFP002*** -JN9ECALC9*** +JPOECALC*** +J6QECALC2***

**Table B-9. 2020 Median Home Value 2020 Regression Results**

Geographically Weighted Regression:		
Number of Features	201	
Dependent Variable	AMWBE001	Median Home Value 2020
Explanatory Variables	AMRZE017	High School Diploma
	AMRZE023	Bachelors Degree
	AMRZE025	Doctorate
	PER_WHITE	Percent White
	PER_RENTOP	Percent Renter Occupied
Number of Neighbors	88	
R2	0.7183	
AdjR2	0.6618	

AICc	5022.4245
Sigma-Squared	3632383543
Sigma-Squared MLE	3028728827
Effective Degrees of Freedom	167.5964
Adjusted Critical Value of Pseudo-t Statistics	2.5554

Best OLS Model fit from Exploratory Regression:

AdjR2	AICc	JB	K(BP)	VIF	SA	Model
0.58	5047.46	0	0	2.21	0.01	-AMRZE017*** +AMRZE023*** +AMRZE025*** +PER_WHITE*** +PER_RENTOP**

## Appendix C – Data Tables for Time Series Charts

Table C-1. Total Population by Year and Tract HOLC Grade

Grade	1940	1950	1960	1970	1980	1990	2000	2010	2020
A	65,596	78,881	87,523	87,916	79,246	76,314	74,351	75,750	79,578
B	300,754	322,720	324,179	309,303	264,896	258,065	259,597	250,406	278,333
C	241,176	254,176	244,773	229,975	191,134	193,609	204,779	196,852	225,658
D	168,957	171,296	135,903	108,164	93,106	100,783	116,344	132,992	159,524
Total Population	776,483	827,073	792,378	735,358	628,382	628,771	655,071	656,000	743,093

Table C-2. Percent Black, African American Population by Year and Tract HOLC Majority Grade

Grade	1940	1950	1960	1970	1980	1990	2000	2010	2020
A	0.05%	0.04%	0.16%	2.04%	2.89%	3.80%	4.36%	5.45%	5.99%
B	0.44%	0.64%	1.74%	4.17%	6.32%	9.90%	11.89%	11.72%	11.05%
C	0.47%	0.71%	2.11%	3.52%	6.59%	12.78%	21.16%	23.71%	23.31%
D	3.67%	4.96%	6.62%	6.56%	10.64%	14.29%	20.11%	25.68%	25.57%

Table C-3. Percent Other Races by Year and Tract HOLC Majority Grade

Grade	1940	1950	1960	1970	1980	1990	2000	2010	2020
A	0.09%	0.10%	0.16%	0.48%	1.50%	2.68%	6.12%	8.51%	11.32%
B	0.48%	0.17%	0.29%	1.15%	3.49%	5.69%	13.81%	15.63%	17.76%
C	0.59%	0.29%	0.76%	2.34%	7.42%	14.00%	28.02%	30.77%	33.35%
D	3.87%	0.46%	1.36%	2.66%	8.04%	14.88%	21.75%	19.67%	20.54%

Table C-4. Percent Rental Occupied Housing by HOLC Grade

Grade	1940	1950	1960	1970	1980	1990	2000	2010	2020
A	31.31%	19.84%	20.38%	24.92%	26.21%	26.58%	25.02%	25.76%	25.52%
B	46.23%	35.38%	35.43%	40.91%	41.43%	41.08%	39.35%	40.85%	40.93%
C	61.64%	53.25%	52.13%	56.40%	56.96%	58.04%	56.11%	61.17%	62.33%
D	76.08%	67.81%	63.21%	66.14%	66.15%	66.53%	65.53%	65.90%	63.57%

Table C-5. Percent Owner Occupied Housing by HOLC Grade

Grade	1940	1950	1960	1970	1980	1990	2000	2010	2020
A	68.69%	80.16%	79.62%	75.08%	73.79%	73.42%	74.98%	74.24%	74.48%
B	53.77%	64.62%	64.57%	59.09%	58.57%	58.92%	60.65%	59.15%	59.07%
C	38.36%	46.75%	47.87%	43.60%	43.04%	41.96%	43.89%	38.83%	37.67%
D	23.92%	32.19%	36.79%	33.86%	33.85%	33.47%	34.47%	34.10%	36.43%

Table C-6. Mean of Median Home Values Adjusted (2020) U.S. Dollars by Year and Tract HOLC Grade

Grade	1940	1950	1960	1970	1980	1990	2000	2010	2020
A	\$119,316	\$150,241	\$170,482	\$158,679	\$211,855	\$203,040	\$272,416	\$406,601	\$387,940
B	\$82,138	\$111,954	\$131,443	\$104,986	\$178,312	\$164,552	\$203,050	\$292,656	\$289,254
C	\$53,212	\$75,515	\$108,024	\$71,406	\$149,350	\$123,584	\$140,295	\$218,606	\$203,940
D	\$33,747	\$47,455	\$99,455	\$54,134	\$143,817	\$126,389	\$151,232	\$250,286	\$239,945

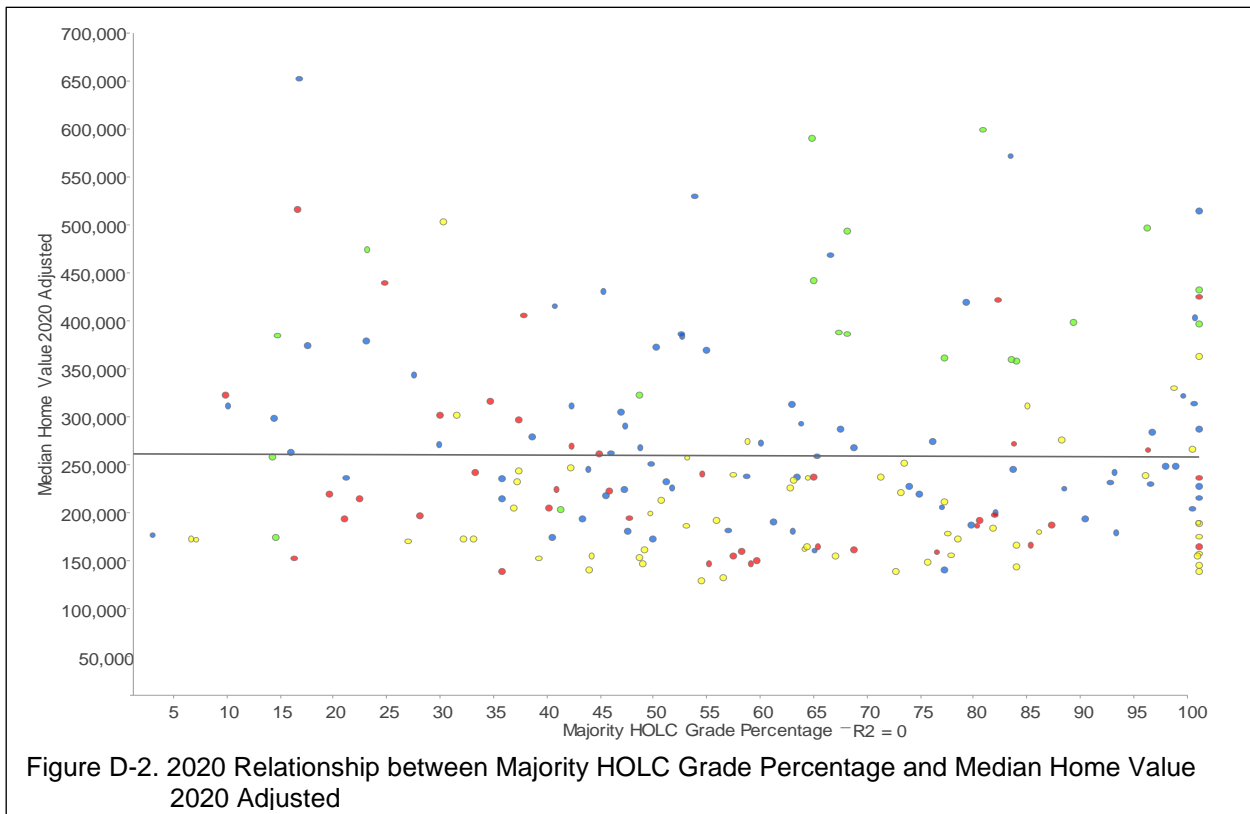
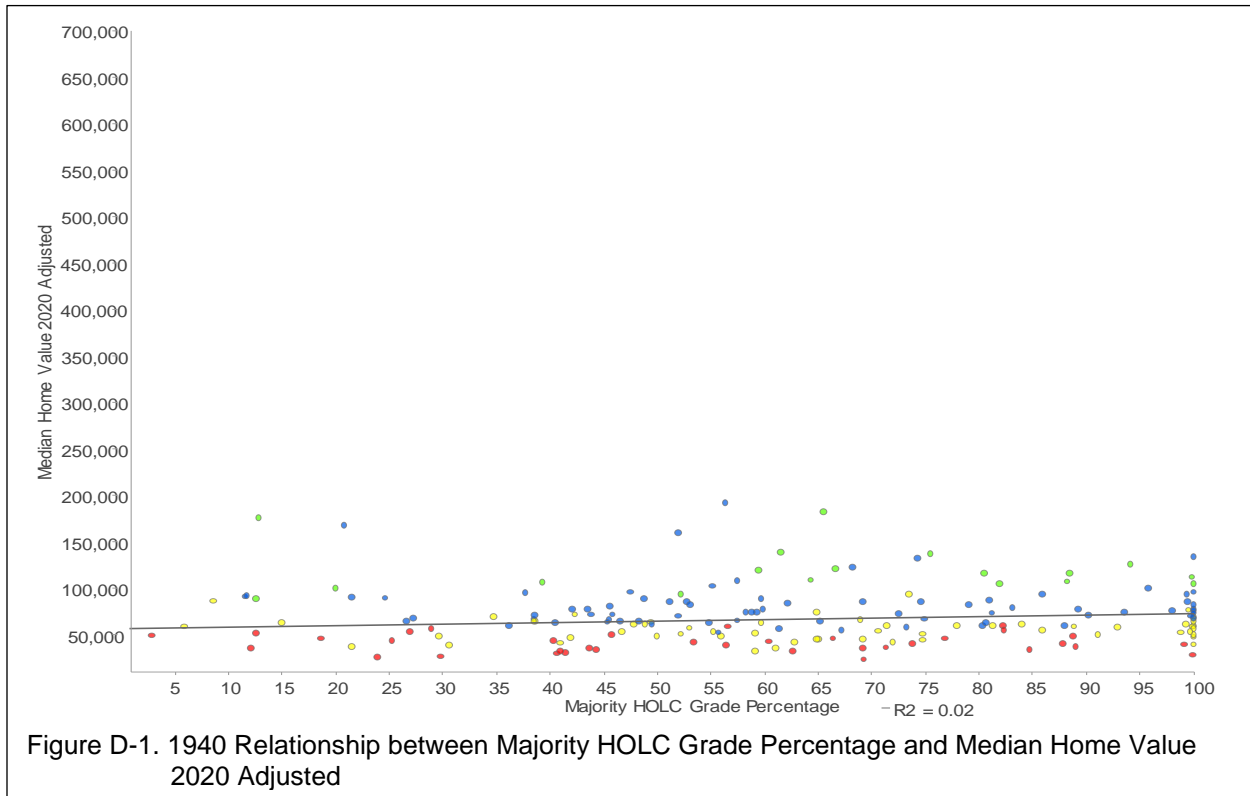
Table C-7. Mean of Median Rent Adjusted (2020) U.S. Dollars by Year and Tract HOLC Grade

Grade	1940	1950	1960	1970	1990	2000	2010	2020
A	\$956	\$623	\$609	\$969	\$997	\$999	\$1,179	\$1,300
B	\$783	\$491	\$686	\$839	\$925	\$924	\$1,010	\$1,103
C	\$577	\$392	\$613	\$734	\$823	\$827	\$924	\$1,021
D	\$440	\$319	\$582	\$641	\$790	\$725	\$888	\$1,082

Table C-8. Unemployment Rate by Year and Tract HOLC Grade

Grade	1940	1950	1960	1970	1980	1990	2000	2010	2020
A	5.03%	1.86%	3.92%	2.59%	2.62%	2.83%	2.70%	5.22%	3.17%
B	8.71%	2.69%	4.13%	3.02%	4.09%	5.30%	4.22%	7.21%	4.34%
C	12.22%	3.75%	3.60%	4.34%	6.09%	8.58%	7.49%	12.56%	6.40%
D	18.72%	6.61%	2.74%	4.56%	6.30%	8.97%	9.19%	10.03%	5.88%

## Appendix D – Selected Scatter Plots





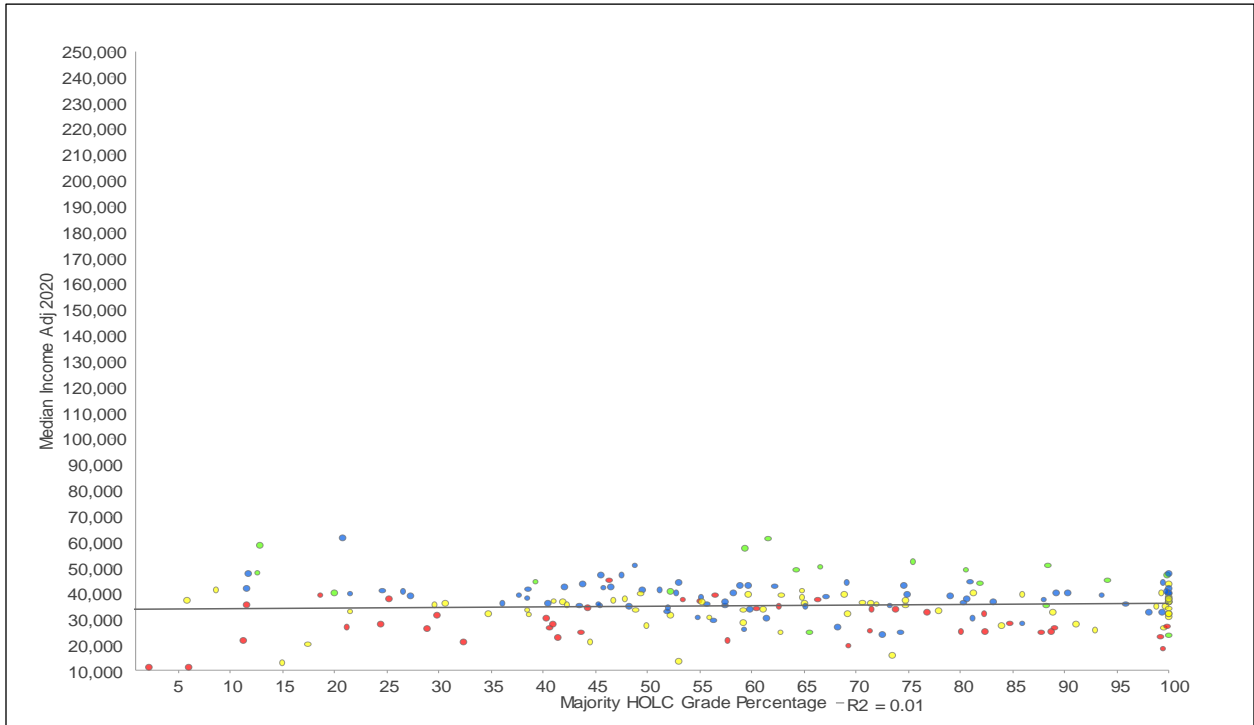


Figure D-3. 1950 Relationship between Majority HOLC Grade Percentage and Median Family Income 2020 Adjusted

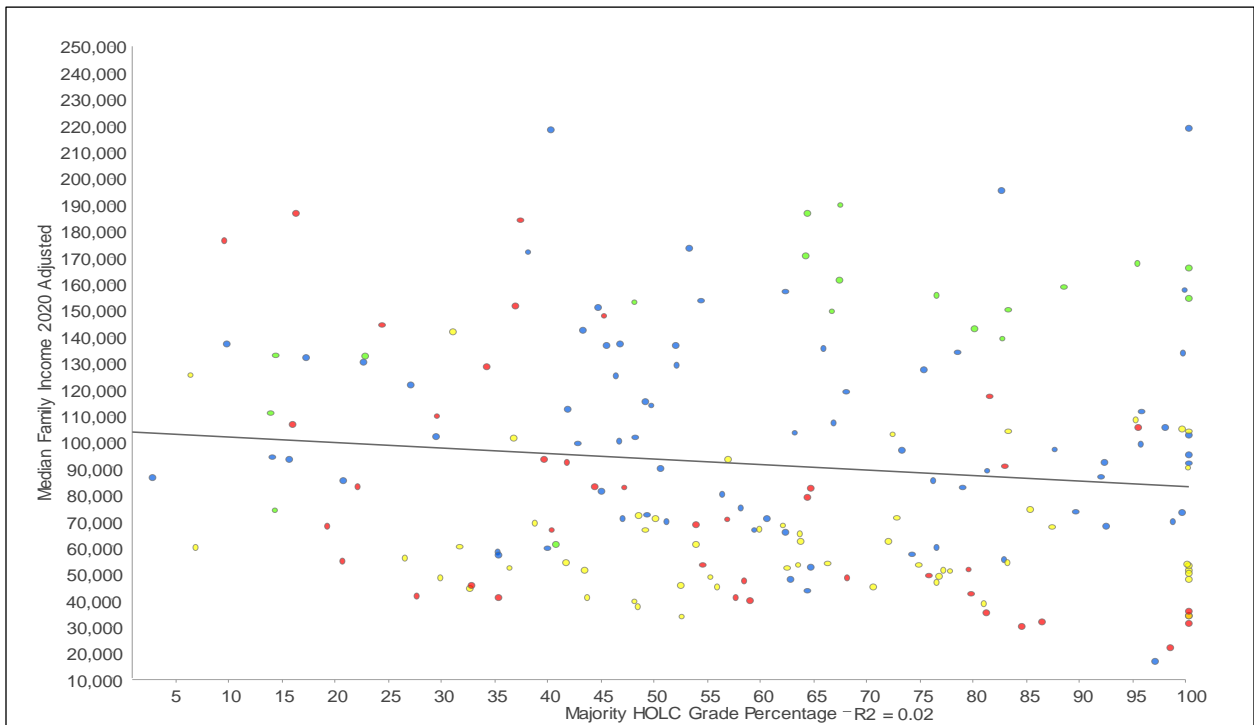


Figure D-4. 2020 Relationship between Majority HOLC Grade Percentage and Median Family Income 2020 Adjusted

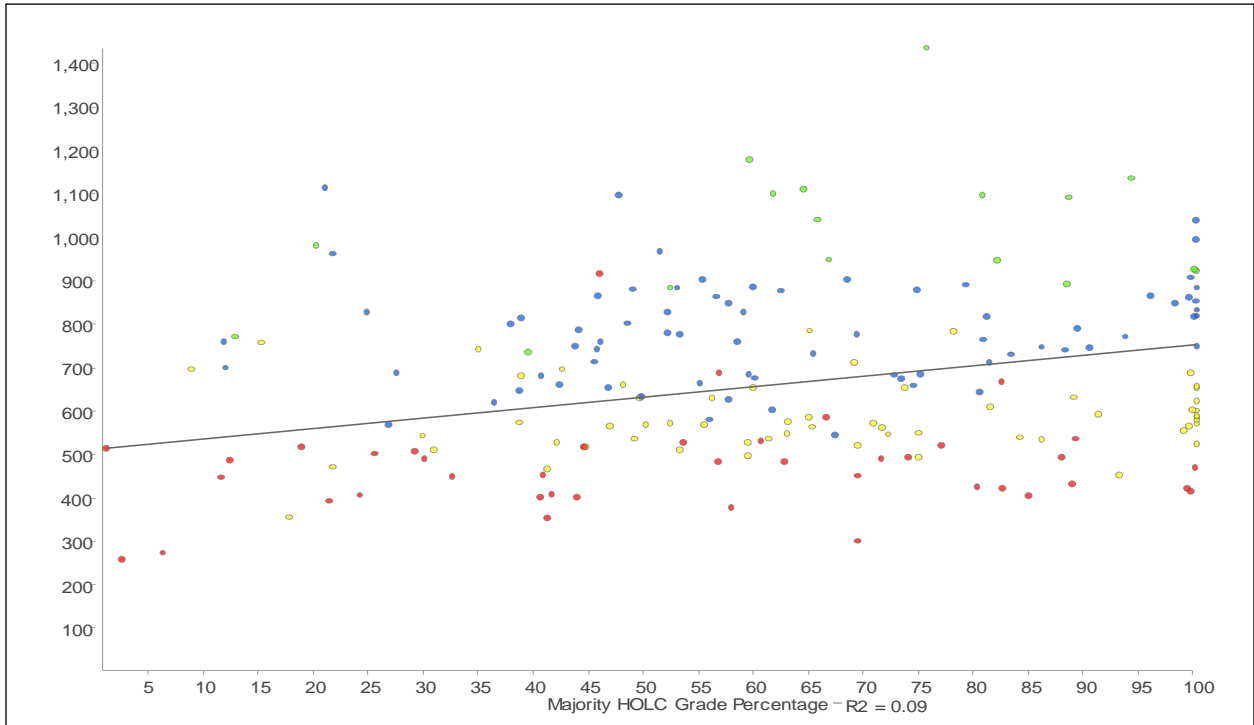


Figure D-5. 1940 Relationship between Median Gross Rent 2020 Adjusted and Majority HOLC Grade Percentage

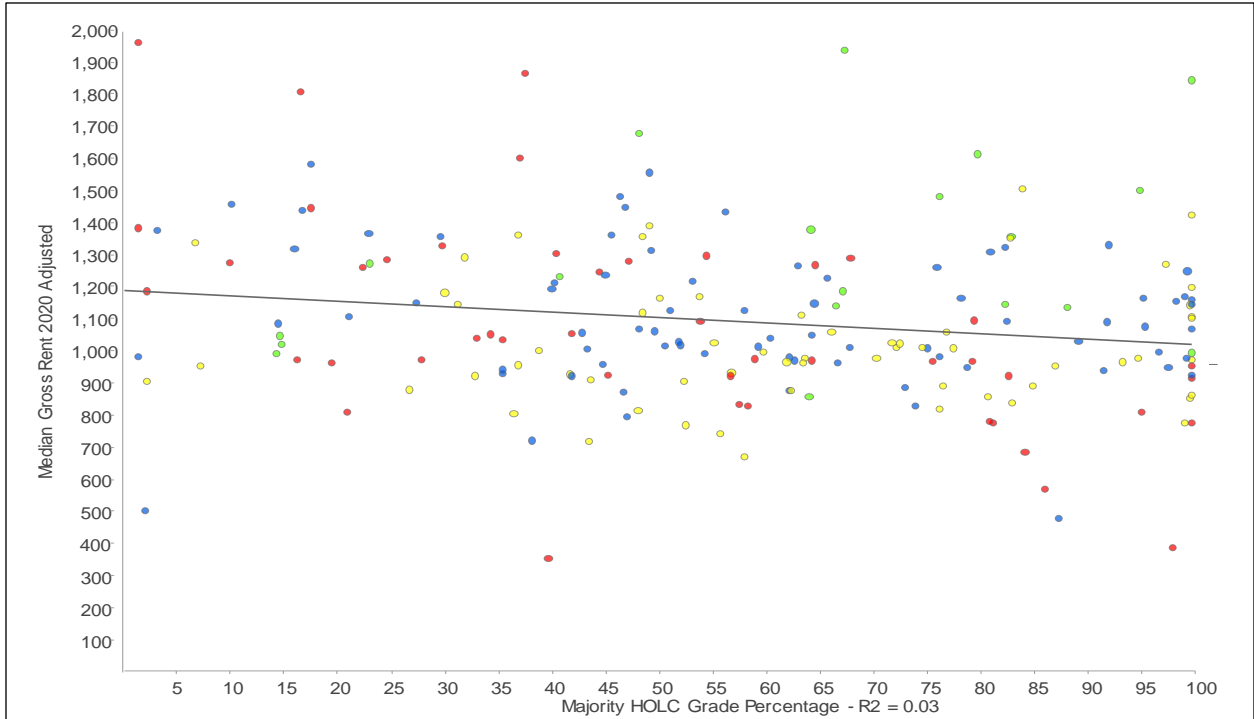


Figure D-6. 2020 Relationship between Median Gross Rent 2020 Adjusted and Majority HOLC Grade Percentage

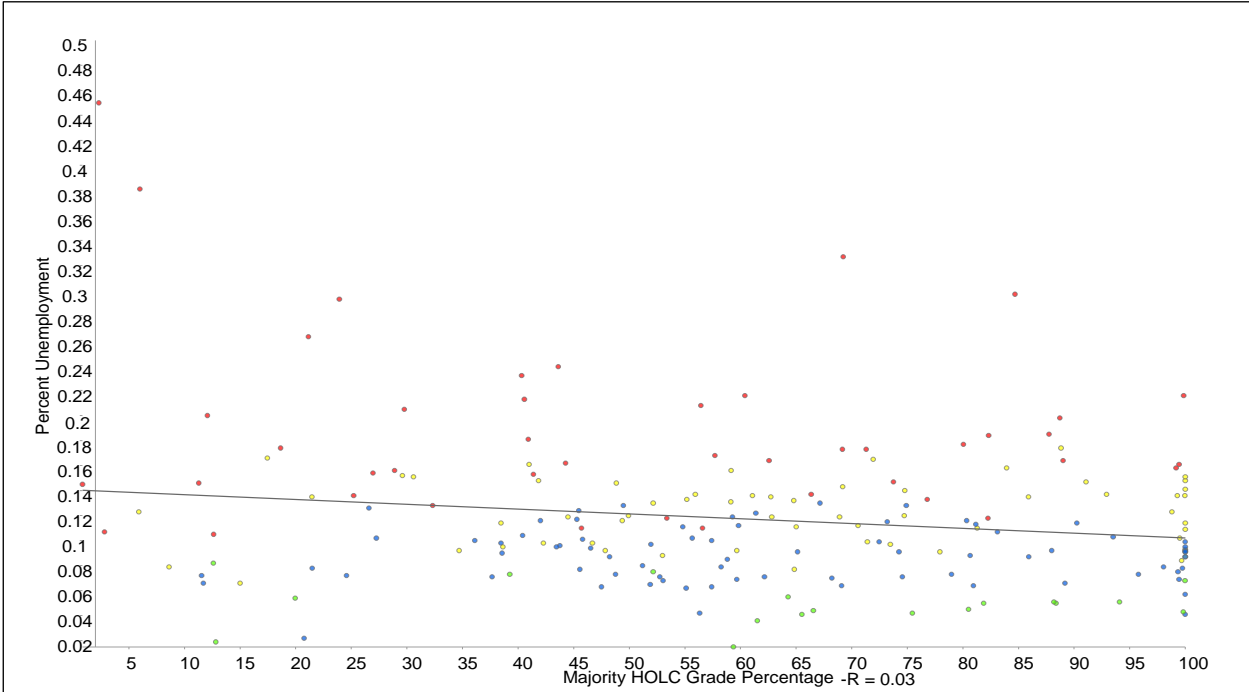


Figure D-7. 1940 Relationship between Majority HOLC Grade Percentage and Percent Unemployment

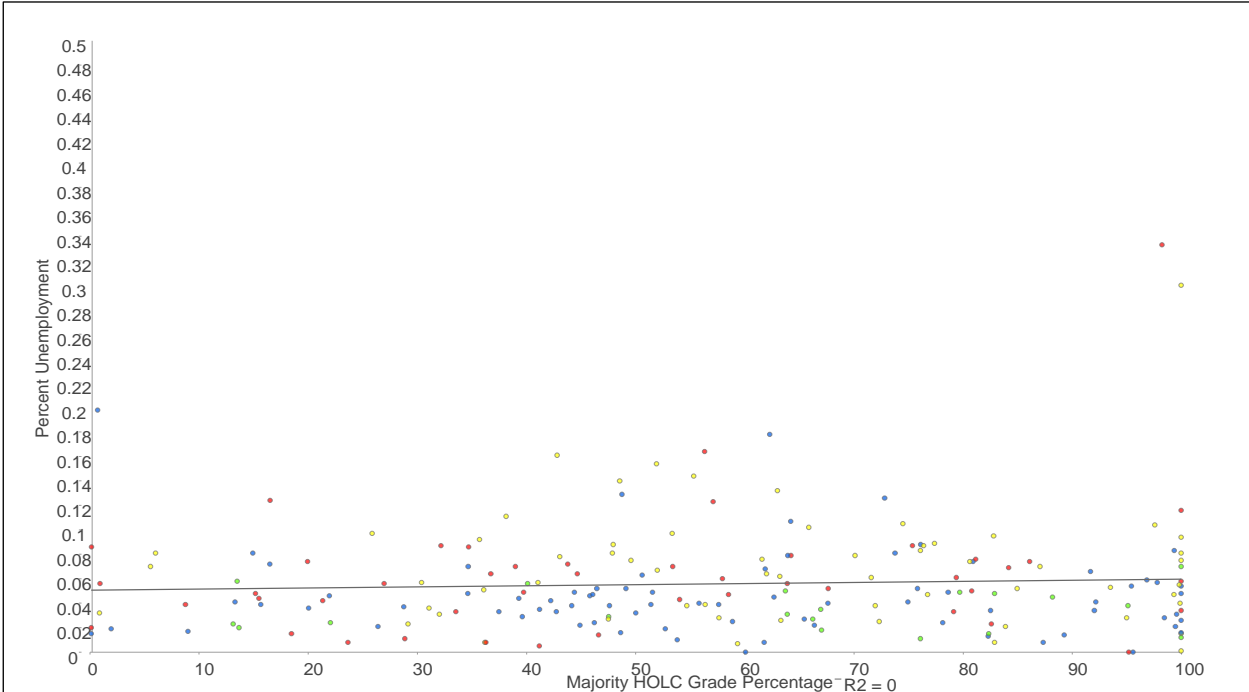


Figure D-8. 2020 Relationship between Majority HOLC Grade Percentage and Percent Unemployment