

# **Predicting Tacoma's Future: Gentrification and Light Rail Transit**

## **Submitted as partial fulfillment of a Master's of Science in Geospatial Technologies**

C.H. Sorge-Toomey<sup>1</sup>

<sup>1</sup>University of Washington Tacoma, 1900 Commerce Street, Tacoma, WA, 98402  
Email: csorge@uw.edu

### **Abstract**

Much has been written about socio-economic changes around light rail systems across the United States, but this capstone will focus on a more nuanced analysis of physical locations of light rail stations in Tacoma, Washington. While sites for light rail stations affect many different aspects of the communities around them, some elements could use more in depth analysis. This project will study how light rail systems change cities with limited or no light rail system in place by creating a model based on examples from existing North American light rail systems. This project will create predictions of gentrification susceptibility in Tacoma. The areas of study will be gentrification and socio-economic factors such as property values, educational attainment, income, and rent. This project will focus creating a comparative analysis of the possible effects of light rail in Tacoma. It will create a model based on examples from the existing light rail system in Tacoma to explore what the effects of this system is and what is to be expected from future light rail projects. The results of the project show that there is an increase in gentrification around light rail stations. It includes in depth modelling of light rail stations and socio-economic changes with an engaging, interactive visualization that allows users to explore different locations of light rail station sites.

### **1. Introduction**

Light rail systems in Tacoma have their roots beginning back all the way in the late 19th century. In 1888, the Tacoma Street Railway began service which consisted of horse drawn carriages that could hold up to 14 passengers. A couple years later in 1890, the first electric streetcar in Tacoma came into service. Many railway companies started up in the following years, but there were only three companies left by 1928, and the whole system died out by the mid 1930s (Dunkelberger 2004). About 60 years later Sound Transit restarted light rail in Tacoma with a vote in 1996 which approved a tax to build a new light rail line. Sound Transit completed five stations in 2003 and an additional station in 2011. There are three new extensions being constructed in the next couple decades. The Hilltop extension will be completed in 2022 and include six new stations and one relocated station. The Tacoma Dome extension will be completed in 2030 and add stations from the Tacoma Dome Station to Federal Way and Fife. The Tacoma Community College extension will be completed by 2039 and include five new stations from Hilltop to Tacoma Community College (Sound Transit 2019). These extensions will change the socio-economic environment greatly. Lessons from the effects of other light rail systems could better prepare Tacoma for anticipated changes.

Gentrification has been defined as “the transformation of a working-class or vacant area of the central city into middle-class residential or commercial use” (Lees *et al.* 2008). Gentrification is inherently class based, and it is not necessarily a racial phenomenon, so this project will focus on the former. For the most part lower-income, working class minorities are replaced by higher income, middle-class minorities in many places (McKinnish *et al.* 2009). Gentrification is a problem in many areas, and new light rail systems can influence the development of gentrification. Investments into transit and transit oriented development can cause gentrification to occur, so it really depends on whether or not the city and planners develop transit oriented development plans. Gentrification of areas around light rail stations vary heavily based on factors such as transit oriented design (TOD) and state-led design programs. Higher property values and rents encourage displacement of existing people, businesses, and social services. Socio-economic factors like income, rent, housing values, and educational attainment are the main indicators of gentrification, but there are others not included in this project. Changes in property value are tied to gentrification, so this project will look at property value changes as well as these other factors.

The main research objectives for this project are 1) find out what the effects of gentrification are, and why it occurs around light rail transit, 2) measure the effects of gentrification around existing light rail transit stations in Tacoma, and 3) predict how gentrification in Tacoma will change as the light rail stations are built and expanded. This will be accomplished by looking at how gentrification affects light rail systems. I used the Mann-Whitney U Test to test for significant differences to answer the second question. I created a web map of the predicted changes that will occur when the light rail station expands to answer the third question. This project will examine how gentrification occurs based on the socio-economic factors stated above. At the end of this project, the final product will be a visualization of how spaces change when gentrification occurs. The first research question about about the effects of gentrification can be answered by looking at existing literature about gentrification and examining the transit investments and TOD principles used for new light rail developments. The second and third research questions will be answered by the analysis and prediction completed about Tacoma.

## **2. Literature Review**

Light rail systems have been growing rapidly in the United States, so my research focused on the changes that light rail systems have on surrounding communities. Gentrification of areas around light rail stations vary heavily based on factors like transit oriented design (TOD) and transit investments. Increasing property values is one effect that gentrification can have on an area. Looking at how property values change as light rail systems are built is one way to observe how gentrification occurs. Whether or not gentrification occurs is based on different socio-economic factors surrounding where these light rail systems are built. The different ways researchers define, and measure gentrification vary based on the socio-economic factors chosen. Baker and Lee’s (2017) study shows that “the impacts of LRT stations can vary depending on local and regional contexts and planning efforts.” Their study focused on fourteen different cities around the United States and found that gentrification differs between cities. The socio-economic factors they focused on were race, education, income, poverty levels, and population density. They found that some areas became richer and better educated while others have relatively higher poverty rates (Baker and Lee 2017). Gentrification of certain areas depends a lot on Transit Oriented Development and local and regional planners who have inclusive designs.

New transit often brings gentrification. There is a lot of literature about gentrification and light rail transit, but there are a lot of differing outcomes based on different situations. One study

looked at the development in Atlanta which was state-led and involved tax increment financing (TIF). The Atlanta Development Authority, the agency that designated the TIF for the Atlanta Beltline, created a development plan that used public funds to improve parks, infrastructure, and transit. The Beltline TIF greatly revitalized some areas around the city and new transit system. Immergluck (2009) found that the Atlanta Beltline in Georgia had a positive effect on residential property values, but it harmed lower-income residents around the new stations. Since property values went up and there were higher tax assessments, the low-income renters in that area experienced pressure to displace from those areas (Immergluck 2009). This displacement had a big impact on lower-income neighborhoods around the new light rail system.

Kahn's (2007) study examines light rail developments in 1970-2000. His measures of gentrification are average home price, average household income, and adults who are college graduates. He studied fourteen different cities to see if there is any effect of gentrification around new light rail stations. Kahn's research found that there are different impacts in different cities. In some cities, such as Boston and Washington, DC, there was an increase in gentrification around new light rail stations, especially "Walk and Ride" stations (Kahn 2007). However, there was no evidence of gentrification in other cities, such as Los Angeles and Portland. Some studies have shown that there is little to no effect on communities around light rail stations if there is no focus on TOD. There is another study that is consistent with Kahn's study regarding no evidence of gentrification in Portland, Oregon. Dong (2017) used five socio-economic variables to measure gentrification: median household income, the share of minority population, the share of young people, the share of small-sized households with one or two people, and educational attainment (Dong 2017). These factors are based on the sociodemographic characteristics of the neighborhood. He also acknowledged that his findings contradicted Immergluck's findings. Dong (2017) speculates that the inconsistency in findings is a result from different "physical and temporal settings" or different research methods used in the studies.

One method of analysis used in a recent study is the spatial difference-in-differences technique to analyze data relating to the causes of gentrification (Bardaka *et al.* 2017). Spatial difference-in-differences was a technique created to address the shortcomings of other techniques used because it emphasizes spatiality. They used socio-economic indicators like income, educational attainment, and housing values in their analysis of the Denver light rail system. The results were that there was an increase in median household income and housing values, but no significant differences in educational attainment (Bardaka *et al.* 2017). Another study used a k-means clustering approach and Markov chains to investigate gentrification in nine cities across the US (Nilsson and Delmelle 2017). Using similar socio-economic indicators to other studies, they found that many neighborhoods are stable over time, but impoverished neighborhoods were more likely to experience changes.

Most studies about property values show that there is an increase in property values at least in a small area around new stations. Kim and Lahr's (2013) study of the Hudson-Bergen Light Rail in New Jersey found that there was a significant increase in housing within one quarter mile of stations, but that increase quickly dropped off farther away from the stations (Kim and Lahr 2013). Another study examined housing prices for single family and multi-family homes within ¼ mile, ½ mile, 1 mile, and greater distances from a rail station in Atlanta, Baltimore, and Portland. It found that access to transit had a positive effect on home values increasing after the 2008 housing crisis (Welch *et al.* 2018). Golub *et al.* (2012) studied the effect of light rail planning, construction, and operation on single family homes, multi-family homes, commercial properties, and vacant land in Phoenix, Arizona. The results showed an increase in value across

the board for single-family homes, multi-family homes, commercial properties, and vacant land (Golub *et al.* 2012). Cohen and Brown's (2017) study examined the announcement of new rapid rail transit on commercial property prices in the Vancouver BC area from 1995 to 2016. The results showed that shorter travel times between residential areas to commercial areas increased the value of commercial properties. This study found that easy access to businesses by using transit helped improve commercial property values and economic growth (Cohen and Brown 2017). These studies show that there is an increase in property values around new light rail stations which can impact rents and have other consequences.

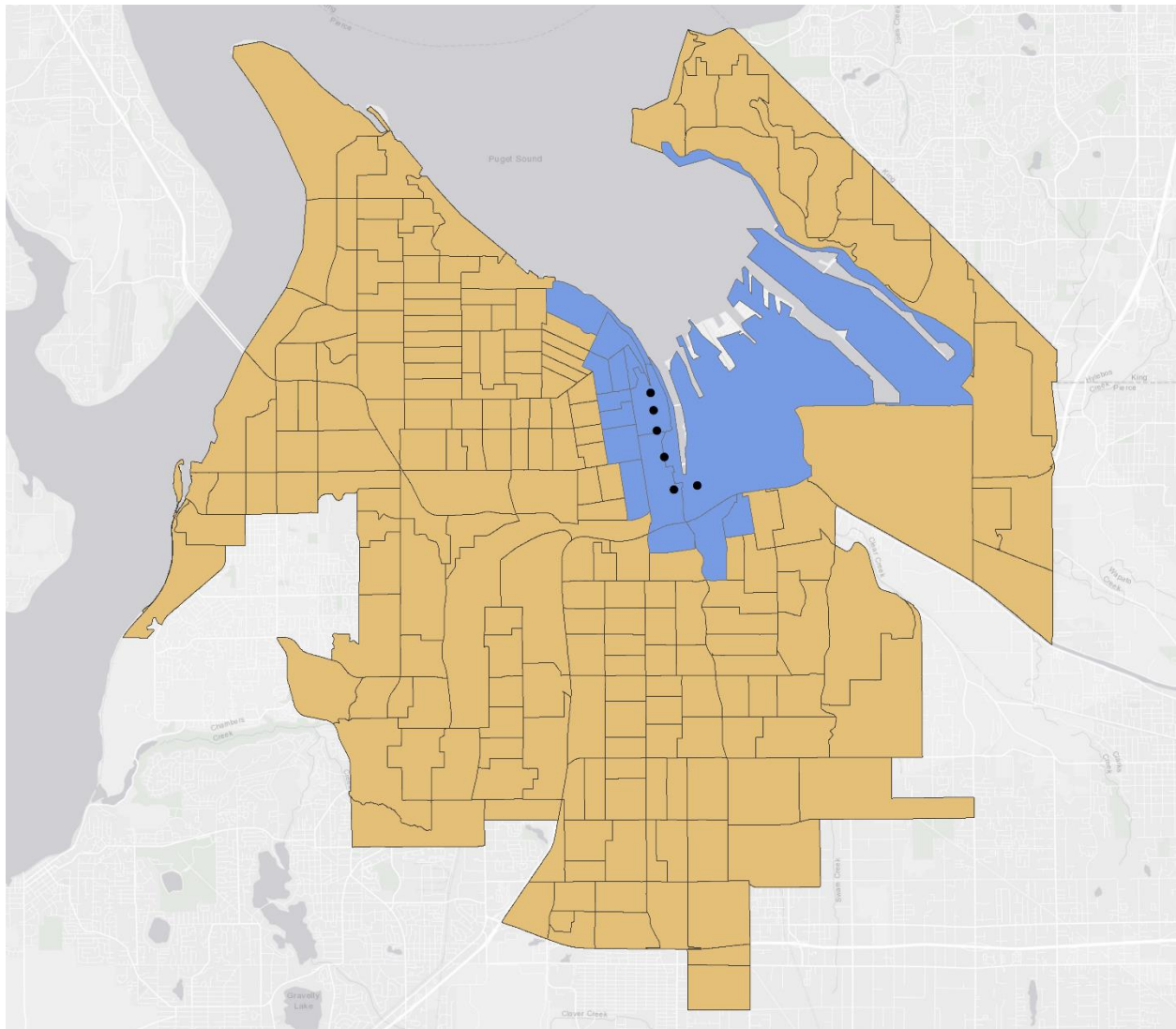
### **3. Description of Intervention**

The final output for this project is an interactive web map that shows the future predictions of gentrification susceptibility in Tacoma. The visualization shows that as the stations are built, the gentrification susceptibility changes. It will start with the newest data from the census (2017) and will have buttons to switch the map to show future years. The data for the future years is extrapolated based on the distance each block group is from the new rail stations built in that year. The indicators used for the model are gross rent, median household income, median housing value, and the proportion of people who have a bachelor's degree or higher. Since it only uses these four indicators it is not a complete analysis, but it gives a general idea of how gentrification will affect Tacoma. The purpose of this visualization was to answer the question of how gentrification will occur in Tacoma. It accomplishes this by showing the potential effects that new light rail stations may have in Tacoma. It also has pop-ups over the rail stations to see which stations are being constructed.

The web map was created using Mapbox. Mapbox is a tool that is used for creating interactive web maps (Mapbox 2019). It was coded using HTML/CSS/Javascript and hosted online via GitHub.

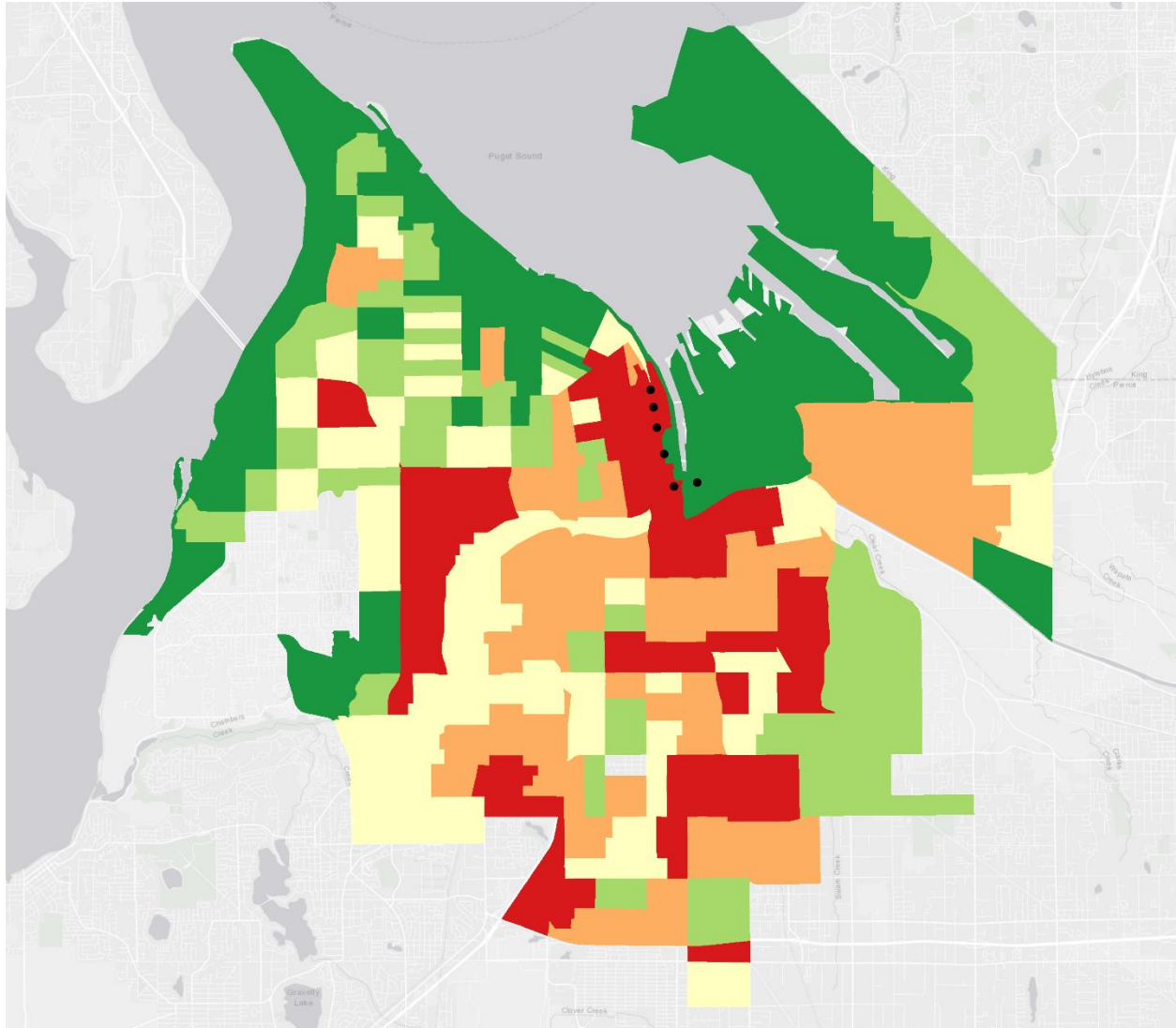
### **4. Methods**

The analysis portion was done in two parts. The first part was using the Mann-Whitney U Test to try to understand if there is gentrification occurring in Tacoma around the current light rail stations. The software used for this test was IBM's SPSS (IBM 2019). This software is used for many different statistical analyses, but the analysis used for this project was the Mann-Whitney U Test. The second part was using a gentrification susceptibility index to see how the new light rail stations could affect Tacoma in the future. The data used for both portions was census data from the National Historical Geographic Information System (NHGIS). This data comes from IPUMS which provides census and survey data for free. It is a curated government data-produced data collection (Ruggles 2019). The data used from IPUMS NHGIS was the data tables, and GIS boundary files. I used block groups and census data from NHGIS because it was easier to get 1990, 2000, and 2010 data from there in one place. The indicators used were median household income, median gross rent, median housing value, and educational attainment (proportion of people with a bachelor's degree or higher). These are the main indicators for whether gentrification has occurred. The distance from each block group to the nearest light rail station was used for the future predictions. The topic of gentrification is complex and has a lot of different indicators, but this project only used four. This means that it is not a complete analysis of gentrification.



**Figure 1. Subset of Tacoma for Mann-Whitney U Test**

A baseline analysis was done to show the differences in the areas around the light rail stations to the whole city using the Mann-Whitney U Test. The baseline analysis was used as a control group, and the predictions built upon it. This test was conducted on the data from the years 1990, 2000, and 2010. The purpose of using this test is to find if the two areas are different during these years. The subset area was a half mile around the currently existing light rail stations. The blue area in figure 1 shows the subset of block groups close to light rail stations. These areas were compared that area with the rest of Tacoma. The area was half a mile because any farther than that would make no difference. The block groups were of variable size, so it was difficult to get an accurate region around the existing light rail stations. Once the areas were determined, the Mann-Whitney U Test was used to test for statistical differences between the two areas. This test is used to determine if the two groups are statistically significantly different. The Mann-Whitney U Test is a non-parametric test which is used when the sample data is not normally distributed. The results of this test will be evaluated in the discussion section of this paper.



**Figure 2. 2017 Gentrification Susceptibility Index**

The next portion of the analysis was determining gentrification susceptibility indices for the years 1990, 2000, and 2010. An index was used for each of these years to determine if the areas around light rail stations were susceptible to gentrification. Indices are used to show if a certain area is susceptible to gentrification based on a scale from low to high. One difficulty in creating indices was that the block groups changed slightly from year to year, so it was difficult to line up them for analysis. The index for 1990, 2000, and 2010 was created using median income, median housing value, median gross rent, and the proportion of people who have bachelor's degrees or higher. The index for 2017, 2022, 2030, and 2039 used these four indicators as well as distance from block groups to the nearest station. The indices were created using z-values assigned to each indicator. The z-values were calculated based on the mean and standard deviation for each of the variables. Once the z-values were obtained it was converted into a scale going from very low to very high susceptibility. Figure 2 shows an example of the gentrification susceptibility index maps. The red color on the map means high susceptibility and the green areas mean lower susceptibility.

After the initial indices for 1990, 2000, and 2010 were created, an index for 2017 was created to use for the future predictions. The 2017 index was used as a base for the predictions of gentrification susceptibility for 2022, 2030, and 2039. The future indices included the distance from the centroid of the block groups to the nearest light rail station. This allows the index to take into account the new rail stations that are built in each future year.

## 5. Discussion

The results of the Mann-Whitney U Test are in table 1, table 2, and table 3. The results show that there was no consistent pattern for the p-values. The data can only be statistically significantly different if the p-value is below 0.05. The p-values for the Mann-Whitney U Test results had no discernable patterns. This means that there was no concrete differences between the two areas, and the data does not support the hypothesis that there were more differences in later years as the stations were built. This test was used to answer the question of whether or not there was evidence of gentrification in downtown Tacoma around the existing light rail stations, but unfortunately there were no conclusive results. Since there were no definitive results, it cannot be assumed that gentrification has occurred in Tacoma around light rail stations. The analysis with the indices had more conclusive results.

**Table 1. 1990 Mann-Whitney U Test Results**

	Median Value	Educational Attainment	Median Rent	Median Income
Z-value	-3.075	-2.304	-5.966	-5.852
P-value	.002	.021	.000	.000

**Table 2. 2000 Mann-Whitney U Test Results**

	Median Value	Educational Attainment	Median Rent	Median Income
Z-value	-1.548	-.225	-4.550	-4.500
P-value	.122	.822	.000	.000

**Table 3. 2010 Mann-Whitney U Test Results**

	Median Value	Educational Attainment	Median Rent	Median Income
Z-value	-4.629	-.937	-5.832	-5.256
P-value	.000	.349	.000	.000

The indices for 1990, 2000, and 2010 in figures 3, 4, and 5 (in the appendix) show that there is an increase in gentrification susceptibility around light rail stations. These indices are based on four indicators: median income, median rent, median housing value, and proportion of people who have bachelor's degree or higher. The gentrification susceptibility indices for 2022, 2030, and 2039 showed that there was more gentrification depending on where the light rail stations were built in future years. The future predictions are available on the online web map and in the appendix of this paper. This result is approximate because it does not take into account any other factors besides the four indicators listed before and also the distance to the nearest light rail station. This means that the analysis was very limited and should have included more indicators

to get a more accurate result. If this project were to be done again it would be better to forecast data for the future years.

Gentrification is a very complex topic and this project was very limited in terms of scope and indicators. Light Rail systems are also very complex and have many different factors that go into creating and building them. This means that this project is not a complete analysis of gentrification or light rail, but it is a basic evaluation and model. Future studies in this area would need to use many more indicators to get a more complete model of gentrification. It would also need to include more considerations about light rail transit. Such as transit-oriented developments and other amenities being built around the new stations. One issue for this project was that the group sizes for the block groups were too small and did not have enough indicators to sufficiently test this complex phenomenon. This led to issues with the data sets being too small for some methods of analysis. The data sets used did not have enough samples to be able to use regular t-tests. Since the data was not normally distributed, a non-parametric test was used. The non-parametric test used was the Mann-Whitney U Test, which is used when data is not normally distributed. This test also requires the variables to be independent, so it was the wrong method of analysis for this project. The test that should have been used is the Wilcoxon signed-rank test, but due to time limitations it could not be changed in time. This test is used for related and non-normally distributed data.

Considerations for future projects in this area would include using a smaller geographic unit and different sample size for the data. This would help with both the statistics test and the indices. A larger number of samples would have helped with the statistics testing by allowing the use of a normal t-test since the distribution would be more likely to be normal. This may have offered more accurate results rather than the Mann-Whitney U Test. A smaller geographic unit would have also helped to get a more accurate half mile buffer around the stations. A more accurate buffer would have helped for the differentiation between the areas strictly within half a mile of a light rail station. In the current analysis the block groups that are supposed to be within half a mile are outside of that range because the block groups have very different sizes. The different sizes skews the data to be more inaccurate. A more robust analysis of gentrification in Tacoma should be done.

## **6. Conclusion**

Light rail transit systems can bring gentrification and changes to the communities around the stations depending on certain factors. The main reasons gentrification occurs are because of transit investments and transit oriented development. Government policies can also influence how gentrification develops. Gentrification usually has a negative connotation associated with it, but it can have positive and negative aspects to it. Lower-income, working class minorities can get pushed out without measures that minimize this dislocation, but gentrification can also revitalize areas and bring growth to different parts of cities. The way this project measured gentrification was by examining socio-economic factors such as median household income, median gross rent, educational attainment, and median housing values to determine the areas where it occurred. The outcome of this project shows predictions of where gentrification may occur in Tacoma which can help planners and policy-makers understand how to reduce the occurrence of gentrification.

This project is significant because it is a predictive analysis specifically about Tacoma, Washington, whereas many studies look at the outcome of multiple areas and existing systems. There have been many projects and research studying already built light rail systems, but this



project examined predicted changes for Tacoma and created a visualization about those changes. Understanding the impact of light rail in other cities helps predict the coming changes to Tacoma's communities.

This project sought out the answers to three specific questions: what are the effects of gentrification around light rail projects, is the area around light rail stations in Tacoma already gentrified, and what does Tacoma's future look like as the light rail system expands. The first question was answered in the literature review. The answer to that is that transit oriented design and transit investments play a big role in gentrification around transit developments. There are also many other factors that are not considered in this project. The second question was supposed to be answered by the Mann-Whitney U Test, but unfortunately there was no conclusive evidence that there was gentrification in Tacoma based on the results. The results from the indices of the areas around the current light rail stations in Tacoma showed that there was higher susceptibility closer to the stations. The 1990, 2000, and 2010 indices showed that gentrification susceptibility was much higher around light rail stations than anywhere else in the city. The future predictions of gentrification susceptibility show that as light rail stations are built, there is more gentrification in these areas.

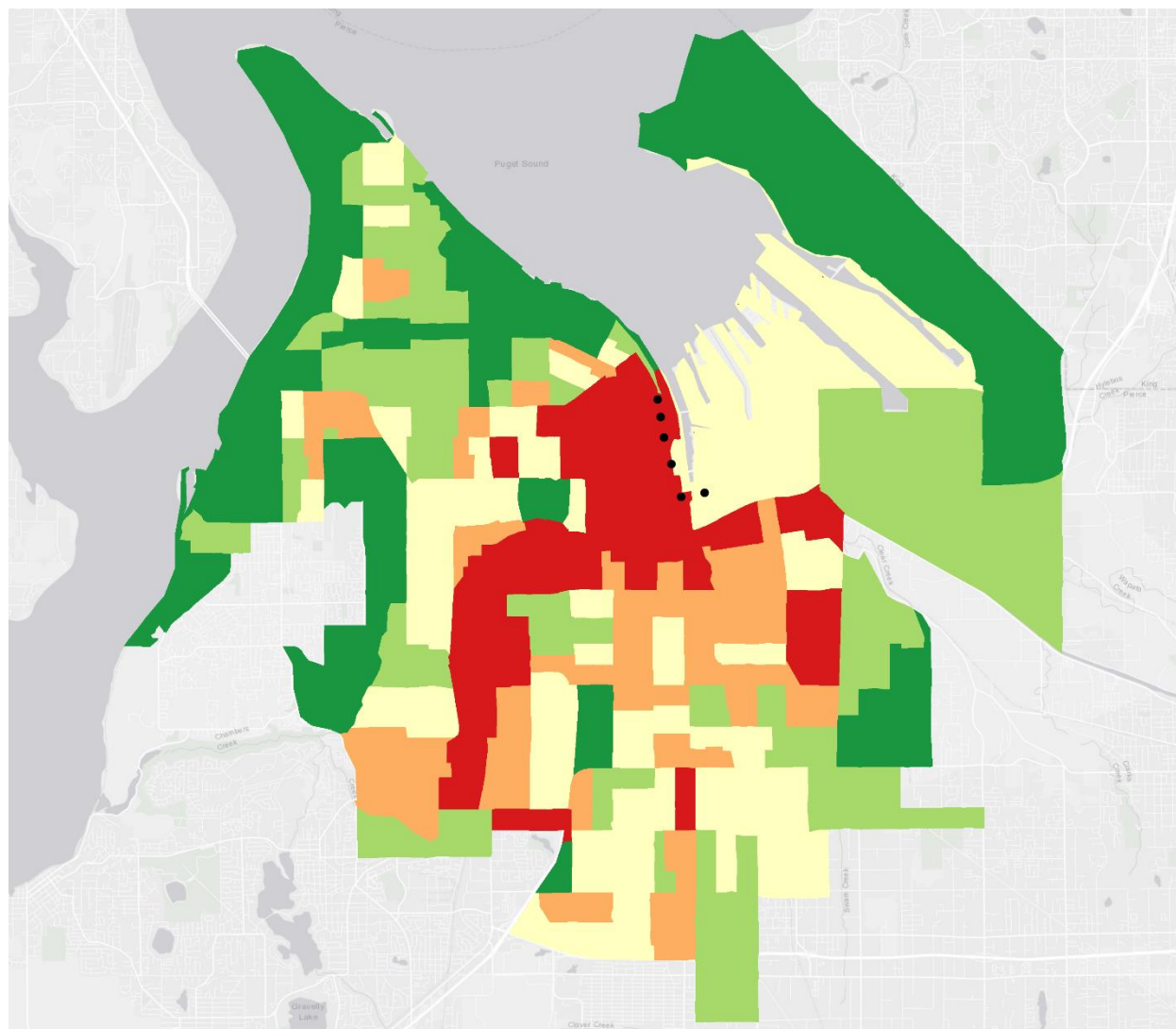
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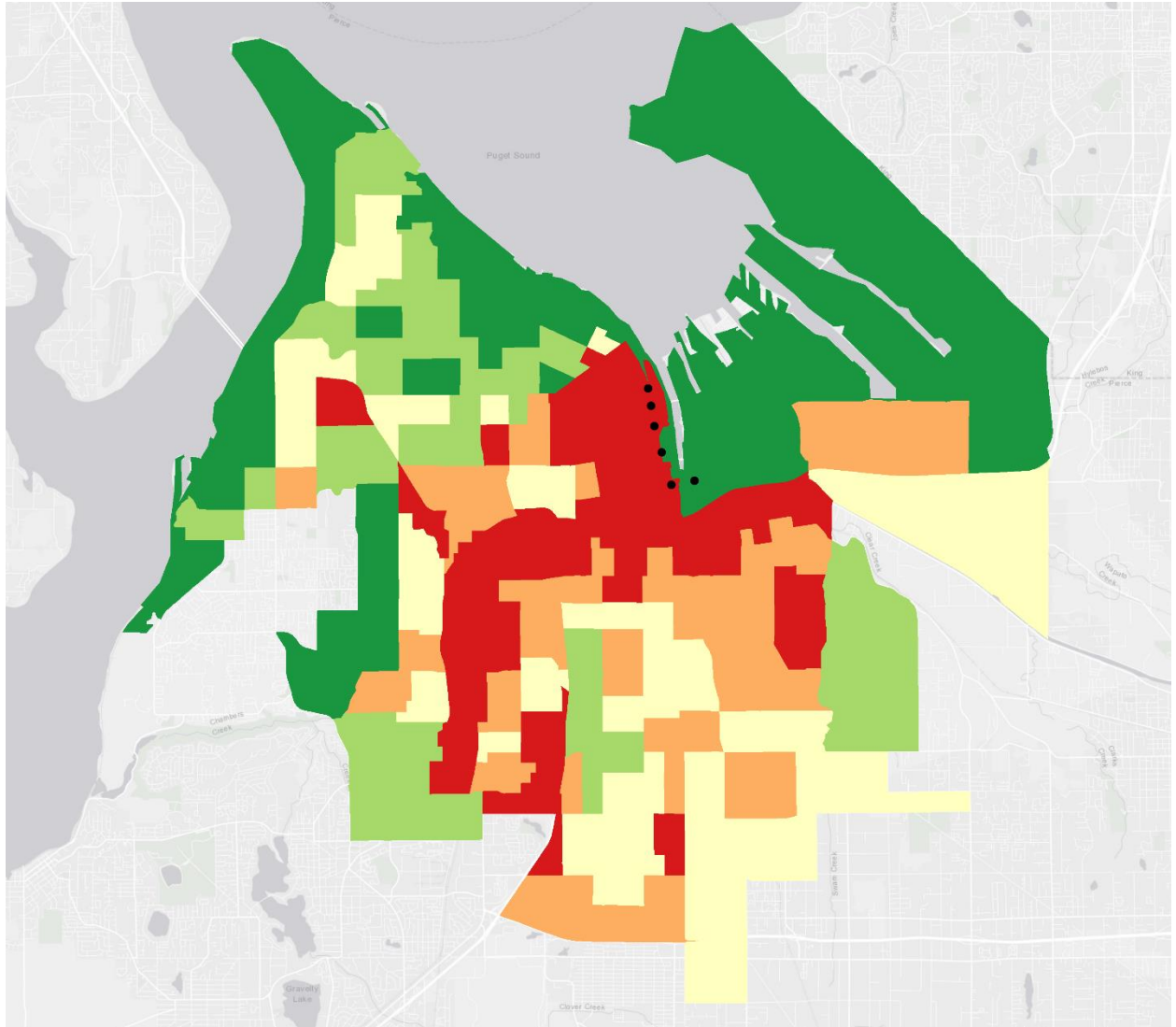
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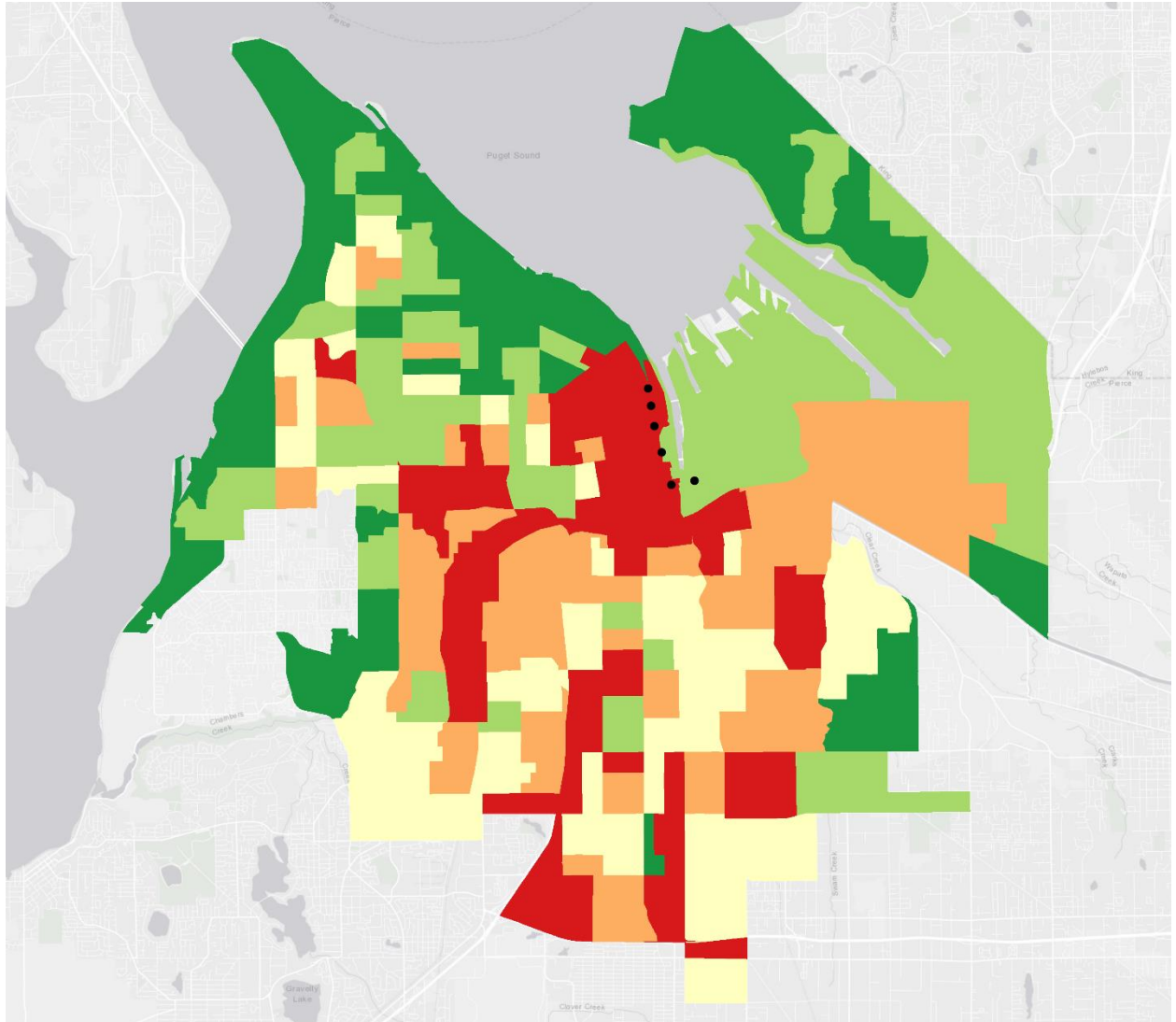
## Appendix



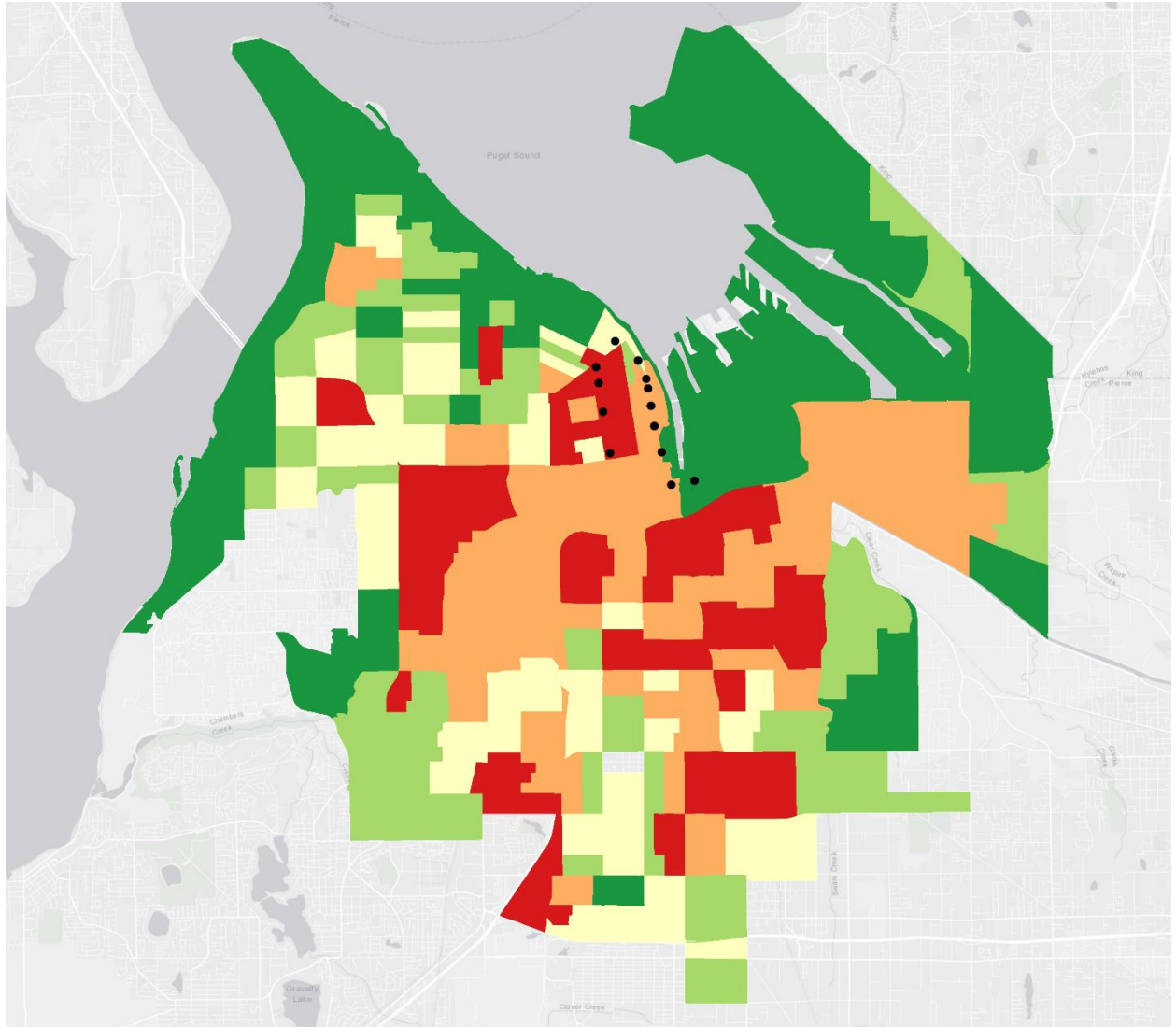
**Figure 3. 1990 Gentrification Susceptibility Index**



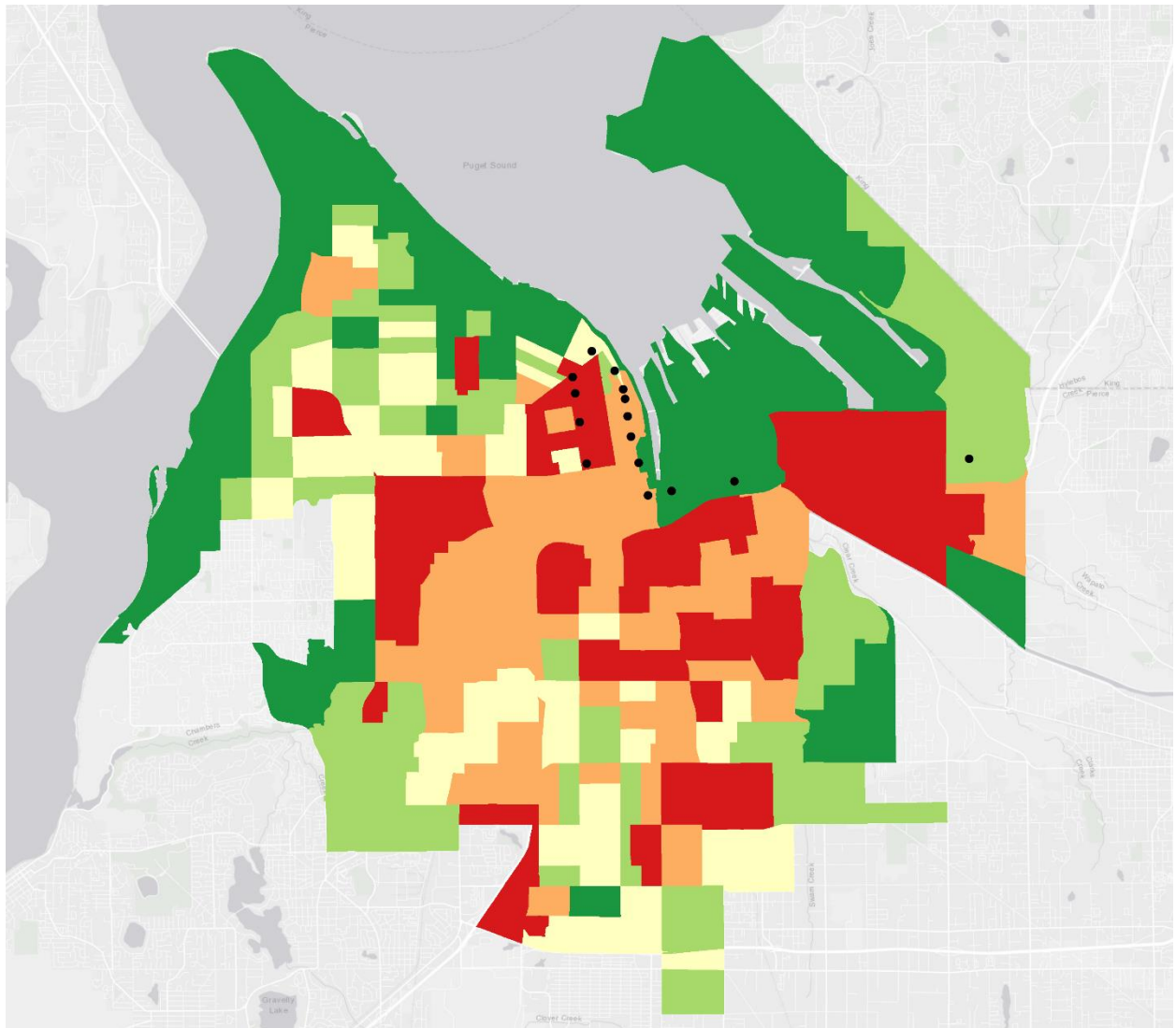
**Figure 4. 2000 Gentrification Susceptibility Index**



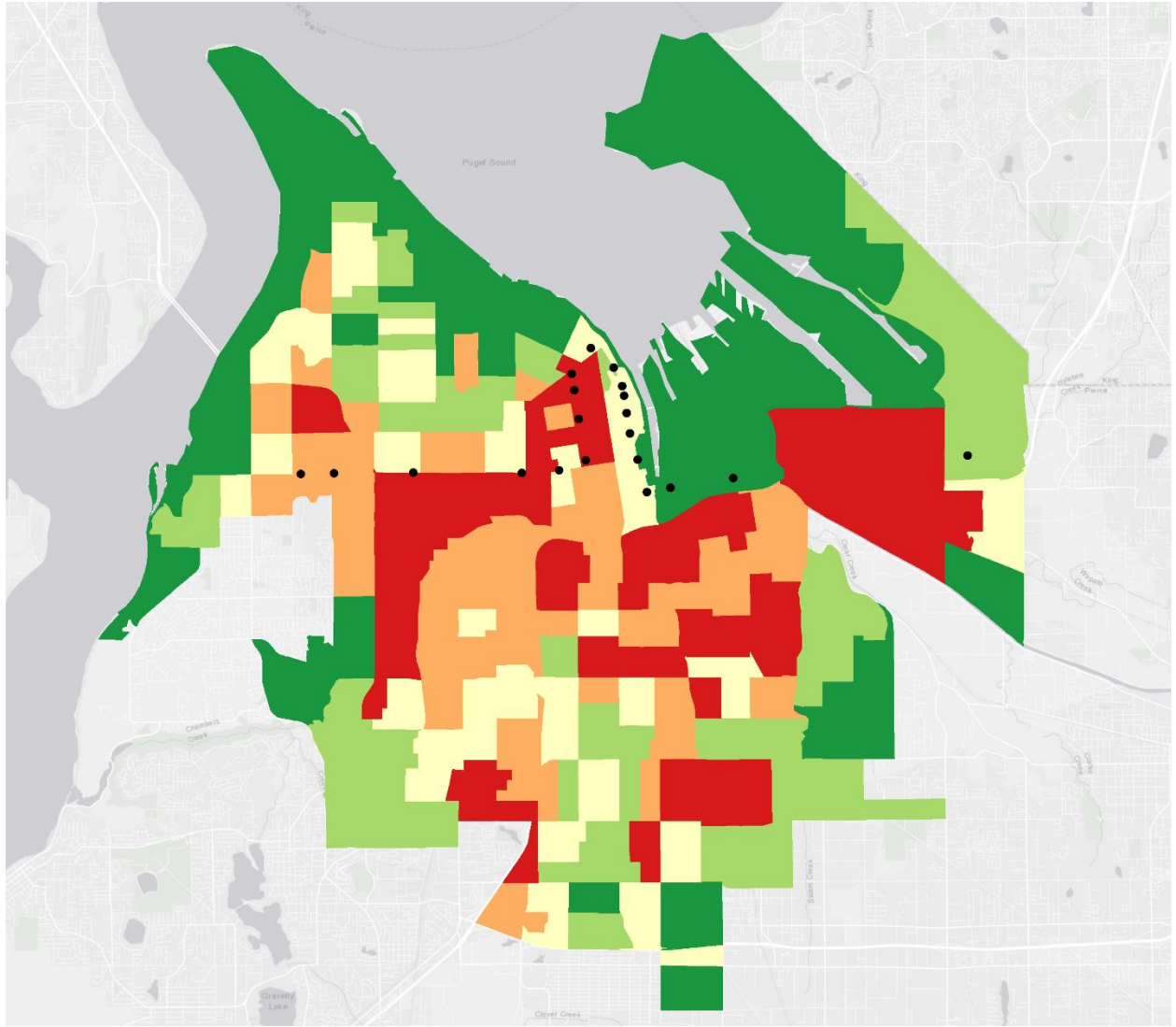
**Figure 5. 2010 Gentrification Susceptibility Index**



**Figure 6. Future 2022 Gentrification Susceptibility Index**



**Figure 7. Future 2030 Gentrification Susceptibility Index**



**Figure 8. Future 2039 Gentrification Susceptibility Index**