Spatial Statistics (Winter 2022) Final Projects in collaboration with the Maryland Department of Planning

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Introduction

The following investigations are from students' final projects for the class Spatial Statistics conducted in Winter 2022 with Professor Rejanne Katell Le Bivic. The class completed these projects with guidance from the Maryland Department of Planning. MDP did not approve or endorse these analyses.

This project was a first experience for many of our students in using census data. Because students were able to choose to investigate any questions of their liking using the census data, there is a wide variety in topics represented by these projects.

Demographic Change 2010-2020 | Ryan James McWeeny

Introduction

Between 2010-2020, Maryland county populations changed in statistically insignificant ways when compared to each other. However, comparing the racial makeup of these counties over time shows major trends. This project will illustrate the statistically significant trends in demographic changes.

Data

All data was collected from the 2010 and 2020 Census conducted by the US Census Bureau and provided by the Maryland Department of Planning.

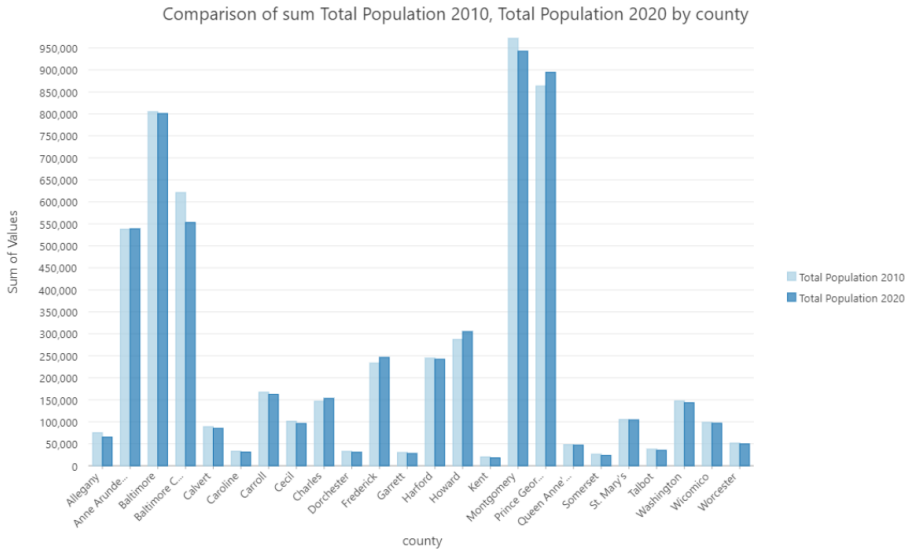
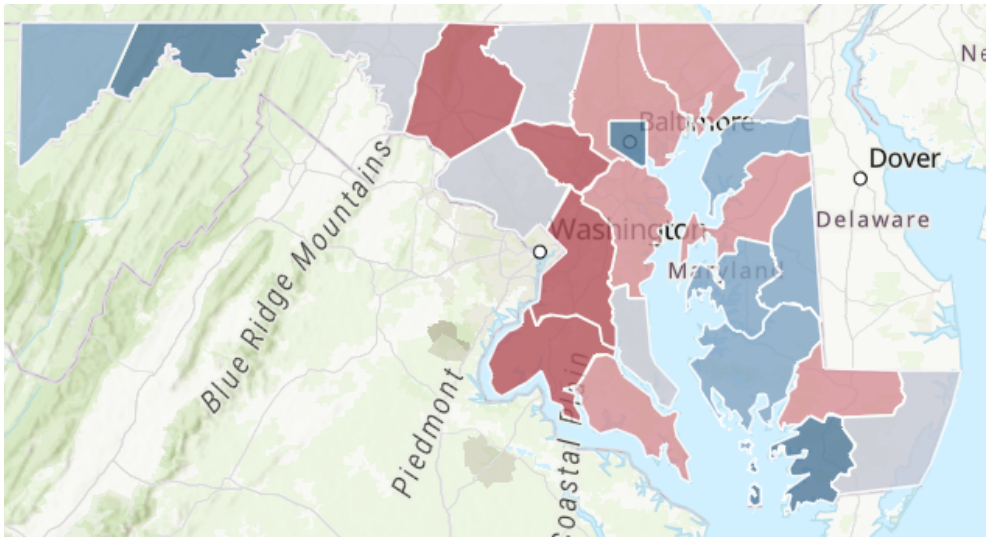


Figure 1. Bar table comparison of 2010 and 2020 populations by county.

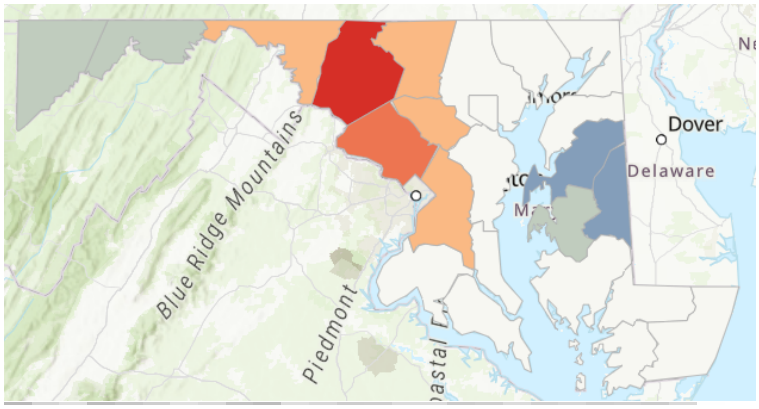
During this decade, the counties with the steepest decrease in population were Allegany, Sommerset, and Baltimore City, each with a drop in total population <10%. Conversely, Frederick and Howard Counties were the only counties to grow in population by over 5%.



We can look at this population change through the bar graph which shows the raw numbers difference (Figure 1), or by looking at percent change for each county (Figure 2).

Black Populations

The analyses deduced that the most significant outliers were a decrease in the black population of Baltimore City and rise in the County, which could indicate a general migration of the black population towards the county. also showed that Frederick County is a hot spot of black population growth.



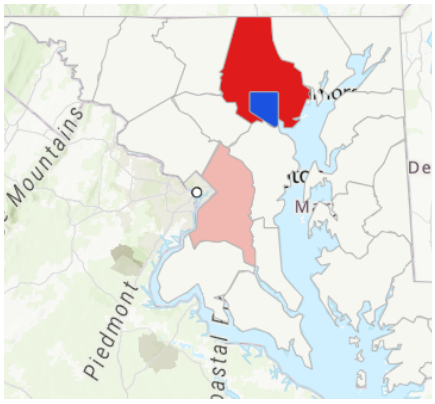


Figure 4. Cluster/Outlier analysis of change in black populations.

White Populations

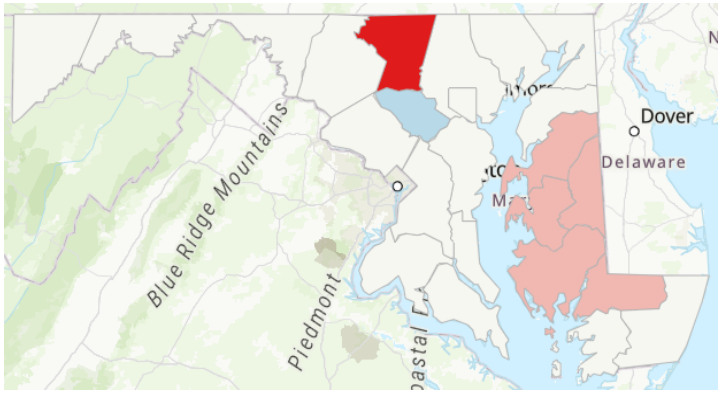


Figure 5. Cluster and Outlier Analysis of Change in white populations.

The same analyses on white populations show that over the last decade Carroll County saw a significant increase in white population, which was uncommon in the surrounding regions. Howard County, just below, saw a lower rate of white population increase. Using hot spot analysis we can also determine with 95% certainty that Prince George's County is a cold spot, meaning this region has a low growth rate in the white population.

Asian Populations

My analysis showed that there are no significant outliers for growth for Asian populations. There is a cluster of high change values in Baltimore County and a cluster of low change values in Calvert County. Baltimore City, County, and Frederick County are hot spots for high growth rate of Asian populations.

Pacific Islander Populations

For Pacific Islander populations, Allegany County is an outlier of lower rates of change compared to neighboring counties. This is an interesting finding because the hot spot analysis shows that Allegany County is still a significant hot spot of high change values compared to the rest of the state.

Indigenous Populations

Hot Spot and Local Cluster analysis on indigenous populations show that Kent County is part of a region that is undergoing a decrease in indigenous populations. Montgomery County has been determined with 95% confidence as a hot spot of indigenous population growth over the last decade.

Ethnic Diversity Index by Census Region: 2020 | Peter Jablonski

Introduction

The state of Maryland is highly varied in its concentrations of diversity and homogeneity. The rural outskirts of the state are generally homogenous, with pockets of diversity in cities such as Hagerstown. The more urban regions closer to the nation's capital, however, tend to be significantly more diverse, and therefore present unique challenges in representing and managing.

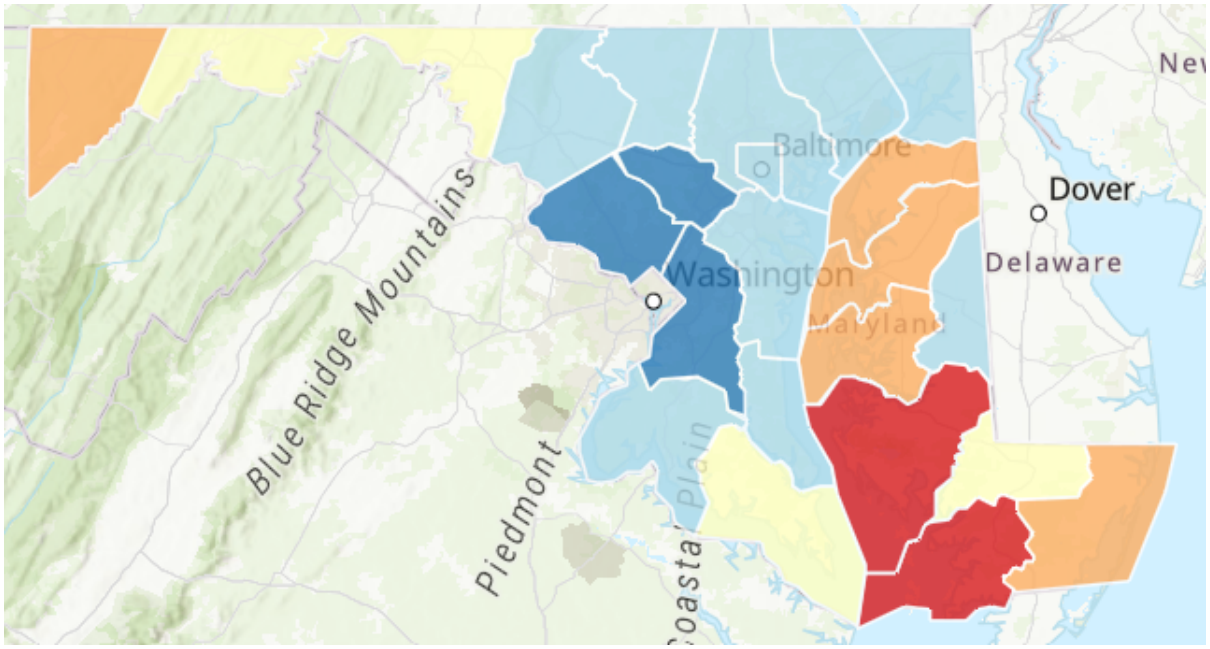


Figure 1. Ethnic Diversity by County.

Goals and Data

This workbook serves as an analytical tool for exploratory analysis of ethnic diversity at various scales within the state of Maryland. Diversity metrics can be examined in the context of geographic census regions (county, tract, block) or political boundaries (congressional or state legislative districts, and their contained census blocks).

Figure 1 shows ethnic diversity by county, while Figures 2 and 3 show ethnic diversity by census block. Scale is a major factor in any census data research. The county level map (Figure 1) is much more clear, identifiable, and can give a good broad overview of which regions of Maryland are more and less diverse. On the other hand, it may miss some nuance that can be seen when looking at a more granular census tract map (Figures 2 and 3).

Diversity scores were derived from 2020 block-level ethno-demographic census data using the Shannon-Wiener diversity indexing method, calculated as a function of the inverse summed product of the natural log of the percentage ethnic distribution as self-reported within each block. Higher scores (Blue) represent more diverse populations, while lower scores (Red) represent less diverse populations.

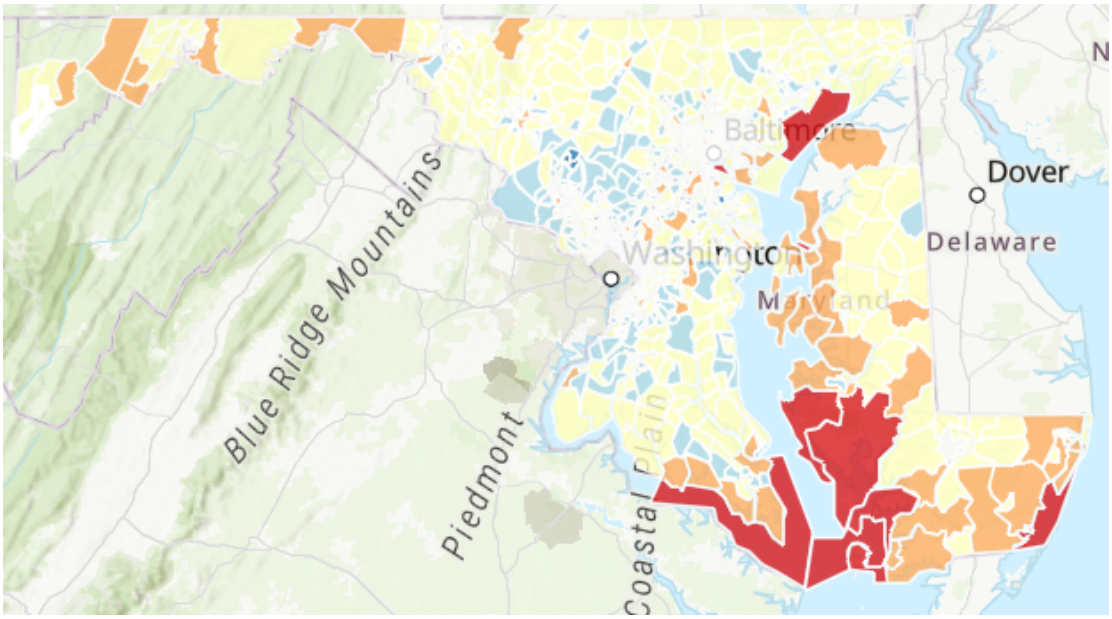


Figure 2. Ethnic Diversity by Census Block (whole state).

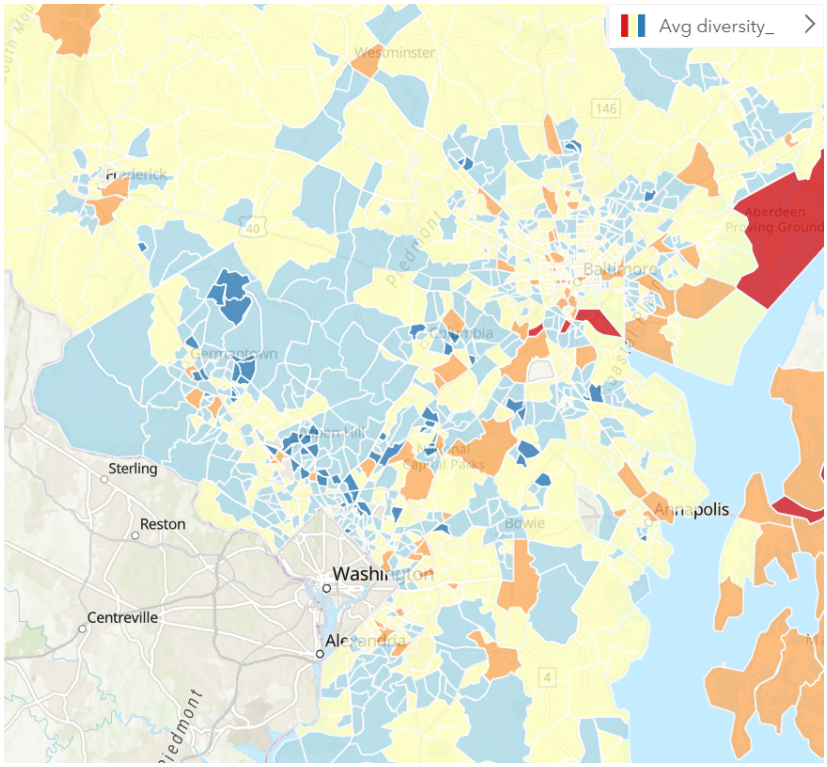


Figure 3. Ethnic Diversity by Census Block (central Maryland).

Results

Both maps show that in general, the eastern shore and western panhandle of Maryland are less diverse, while central Maryland is much more diverse.

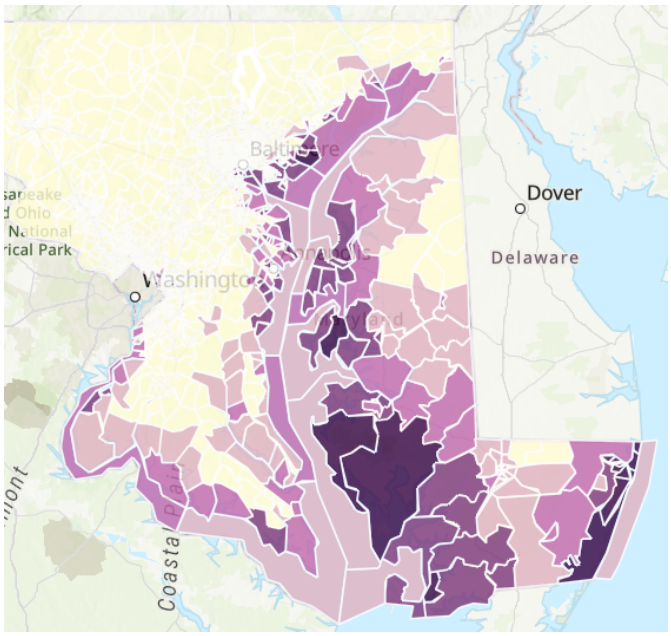
Looking at the county-level map (Figure 1), we can see that Howard, Montgomery, and Prince George's Counties are the most diverse. When looking at the zoomed in census tract data (Figure 3), we can also see large amounts of blue (more diverse) areas.

The more detailed census tract data allows us to see exactly which locations within the diverse counties (Howard, Montgomery and Prince George's) are most ethnically diverse. Using the census tract data we are able to see more details and see variations *within* the county. However, the map (Figure 2) as a whole is difficult to interpret quickly, and the county map has an advantage if the goal is for the viewer to understand general trends rather than granular details.

Maryland Race, Income, and Climate Change Risk | Blake Weimann Munshell

Introduction

Sea level rise poses a major threat to many areas in Maryland. This project aims to examine if race and income intersect with the risk of sea level rise in Maryland.

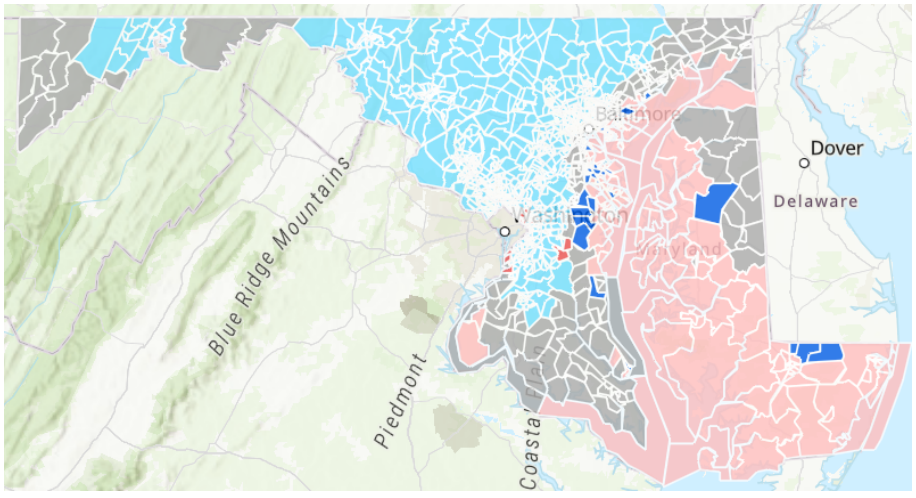


Methodology

Data provided by the ACS on race and demographics was joined to census tract shapefiles. Then data from Maryland Critical Areas/Towns, Maryland nuisance flooding, Flood Risk Indices, and a digital elevation model were calculated into a risk raster, where the mean risk was calculated at a tract level and joined to the census tract data.

First, spatial autocorrelation was conducted and I determined whether and where the data was clustered or not. Exploratory analysis and regression were conducted to assess correlations.

Figure 1. Calculated Risk for Adverse Effects of Climate Change



Calculation of risk

Risk was calculated by taking the average risk using 5 datasets, including a digital elevation model, two critical area layers from the MDOT, and land cover information. Results of a Moran's I show that the risk of adverse effects

due to increased sea level rise is significantly clustered.

Figure 2. Local Moran's I Cluster/Outlier Risk of Sea Level Rise

A Local Moran's I Cluster/Outlier analysis (Figure 2) shows the shore has clusters of high-high values, which makes sense as these areas are on the water. There are also a few small pockets of high risk on the Potomac near DC surrounded by low-risk tracts.

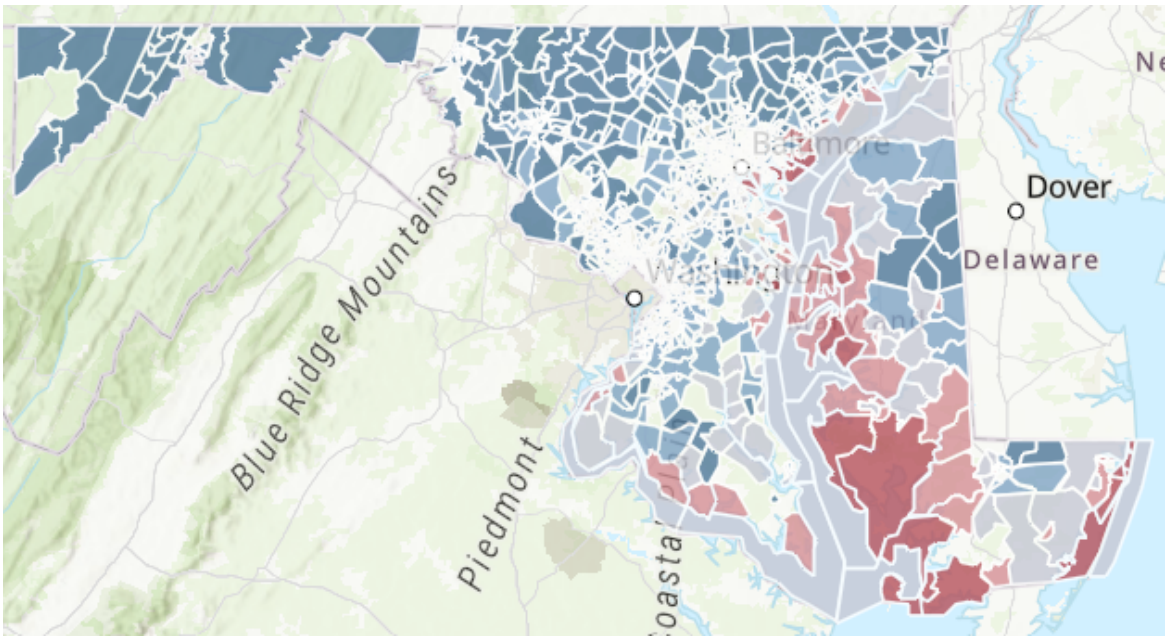


Figure 3. OLS Standard Residuals using Populations in Poverty

	Coefficient of Determination
Risk vs Extreme Poverty	0.000
Risk vs Percentage Black Population	0.038
Risk >0.1 and Extreme Poverty	0.000
Risk >0.1 and Black Population	0.022

Correlation with Race and Income

Likely due to the large number of tracts with very low risks, there tends not to be any trends of correlations found between income, race, and risk. There are many factors to explain this, such as the poorer and majority-minority populations tend to live outside of DC and Baltimore, not on the eastern shore.
However, if you remove the tracts where risk is 0, thereby assessing the demographics of regions with some risk, you find that there is much more of a correlation.
However, in both circumstances there is a very low coefficient of determination and slope associated.

Table 1. Risk and Correlation

Conclusion
Maryland is a very difficult state to assess in terms of race because it has pocket of high minority populations, pockets of majority-white regions, as well as pockets of extreme poverty despite being the richest state in the country. This study attempted to parse this data and assess unequal effects from sea level rise due to climate change.
Sea level rise is a global threat and is already dramatically impacting the US. The northeast is one of the regions most impacted by high tide flooding. While the rate of sea level rise is already bad, that rate is accelerating, so the need for mitigation is greater than ever. Floods in Maryland have already caused great damages to Maryland livelihoods causing significant property damage, loss of life, and decreased tourism.

Vacant Housing in Maryland: 2010 | Luc Benjamin Renaux

Introduction
Areas with high unoccupied housing, especially in urban centers, can be prone to fires, pose a threat to neighborhoods and be a sign of depopulation. The goal of this study is to determine if there is spatial autocorrelation of the percentage of vacant housing on the census tract level. If there is spatial autocorrelation, where are the hot spots and cold spots located?

Methodology and Results
First, I joined housing data to census tracts. Then I calculated the percentage of vacant homes to compare tracts. Spatial autocorrelation tests were performed on these data for the rest of this project.

Spatial Autocorrelation Report (Global Moran's I)

Moran's Index	0.333357
Z-Score	103.162644

Interpretation	There is a <1% likelihood this clustered pattern could be the result of random chance.

The first test performed was the Global Moran's I, in order to see if there was a spatial autocorrelation. The results of the test indicated the vacancy percentages were clustered with a very high confidence. To determine where the clusters and hotspots are within the tracts, more tests are required.

Table 1. Spatial Autocorrelation Report (Global Moran's I)

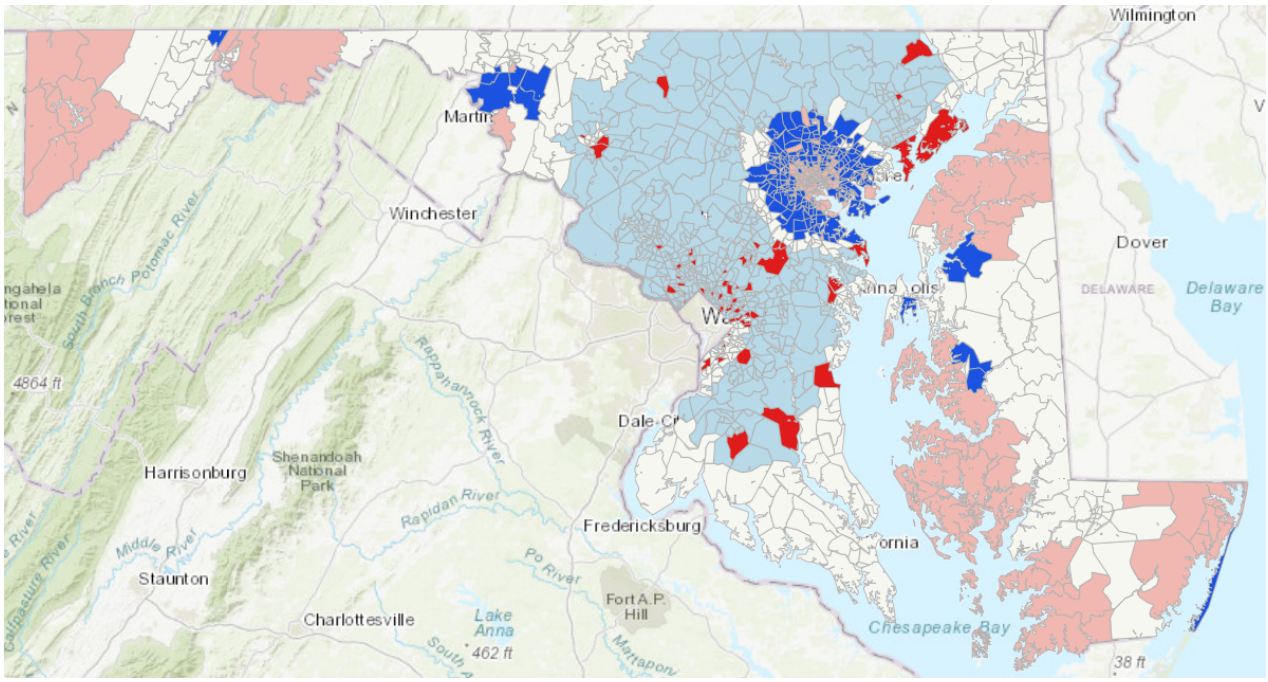


Figure 1. Vacant housing percentage clusters and outliers (Local Moran's I)

The results show a cluster of low vacant housing forming an S-shape in the middle of the state, and high clusters in the rural east and west as well as Baltimore City. A ring of outliers in Baltimore County surrounds the City, indicating a lower percentage of housing vacancies than the city itself. This makes sense as Baltimore has been suffering population decline. Smaller negative and positive outliers are scattered throughout the state, likely the result of smaller population shifts.

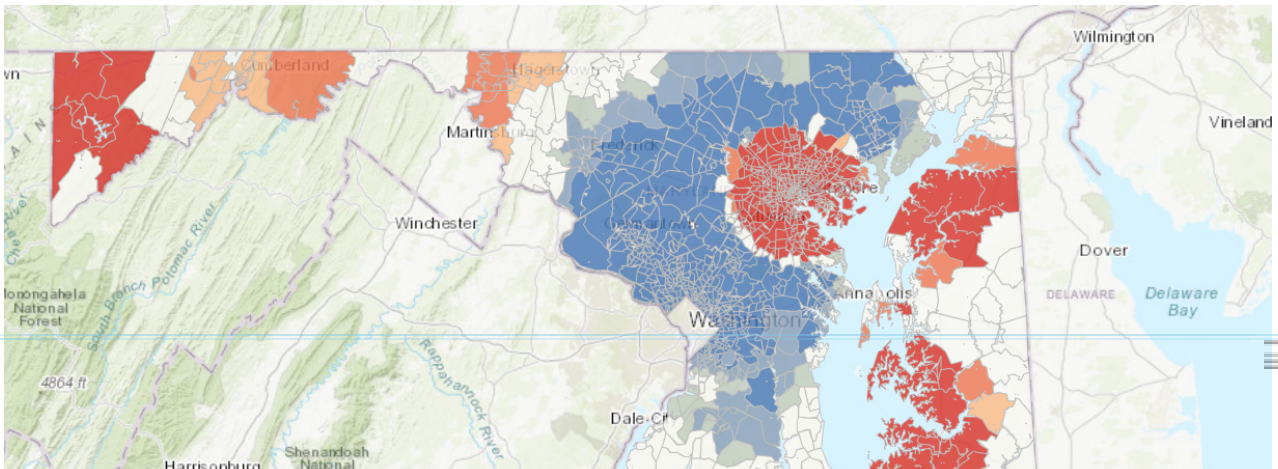


Figure 2. Vacant housing percentage hot and cold spots (Local Getis-Ord G Statistic)

This analysis concurs with previous results. Cold spots of housing vacancy surround the city of Baltimore, while the city and the rural areas of western and eastern Maryland are hotspots for vacant housing.

Conclusion

The results of this project support the original hypothesis. The results of the Global Moran's I test indicated that there was spatial autocorrelation between the percentage of vacancy values of the 2010 Marylnad census tracts. The results of the Local Moran's I test located the high-high and low-low clusters around the predicted locations (Baltimore City and rural extremities for high-high and the middle suburbs for low-low). Lastly, the Getis-Ord hotspot analysis further confirmed the locations of the hotspots and coldspots predicted. These results could likely be due to changes in populations, as rural areas in eastern and western Maryland and Baltimore City have been dealing with the population loss to the suburbs of Maryland. Further studies could be concentrated on areas such as Baltimore City, were the inclusion of the entire state's data might muddle smaller local trends.

Home Ownership in Maryland | Karl Joseph Logan

Introduction

As shown in the previous projects, vacant housing, income, race, and other factors captured by the census all intersect. Home ownership is another facet heavily influenced by the issues previously explored. This analysis looks at trends in home ownership in Maryland, such as age, housing units, and ownership over time.

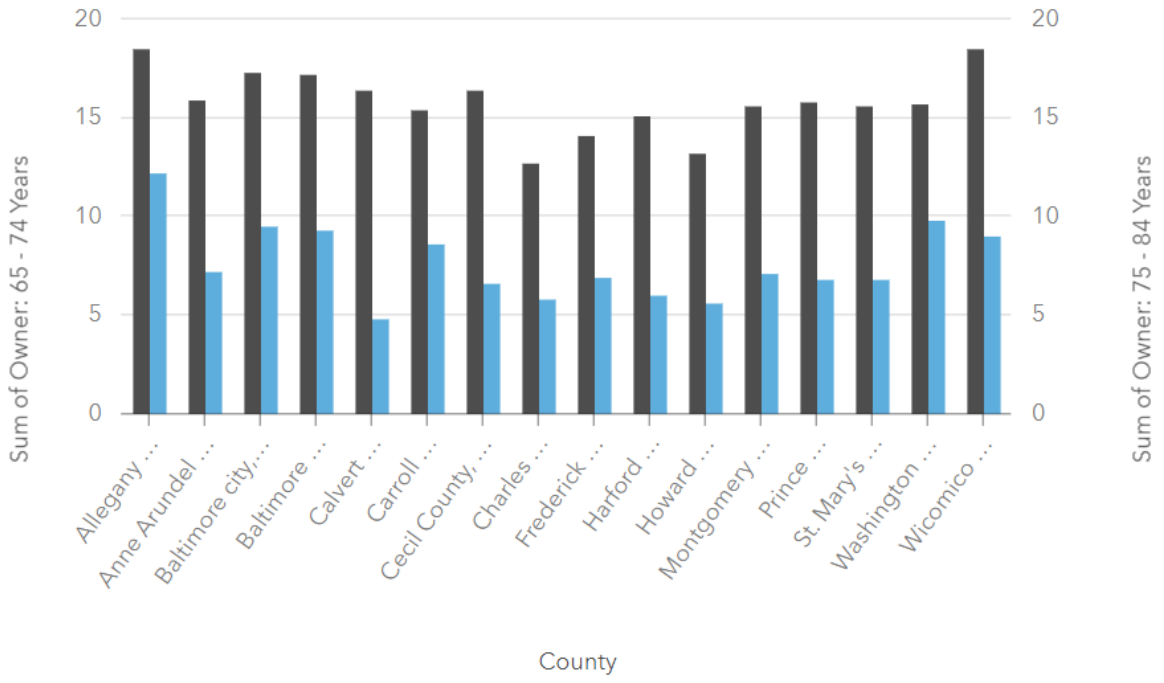


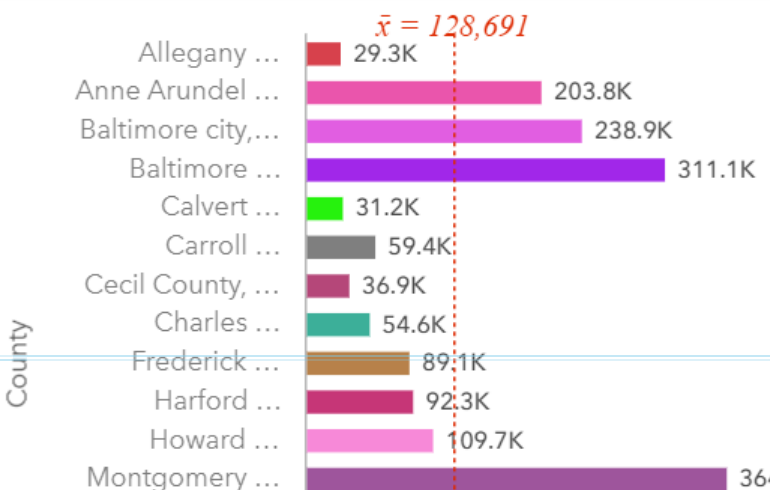
Figure 1. Homeowners 65-74 years old vs Homeowners 75-84 years old.

Age

Figure 1 shows a breakdown of each Maryland county and the age of homeowners for each. We can see that there is a drastic difference in home ownership between the age categories of 65-74 years and 75-84 years across all counties. This could be due to many factors, including but not limited to the fact that older people might need to reside in special care homes as their health declines, or many people may want to downsize their homes once their kids are established adults.

Further insight could be gleaned by looking at multiple age categories across a lifespan, to see broad trends in age and home ownership. It might also be interesting to see generational differences to see if the cost or ability to own a home has become more or less difficult over the past few decades.

Housing Units



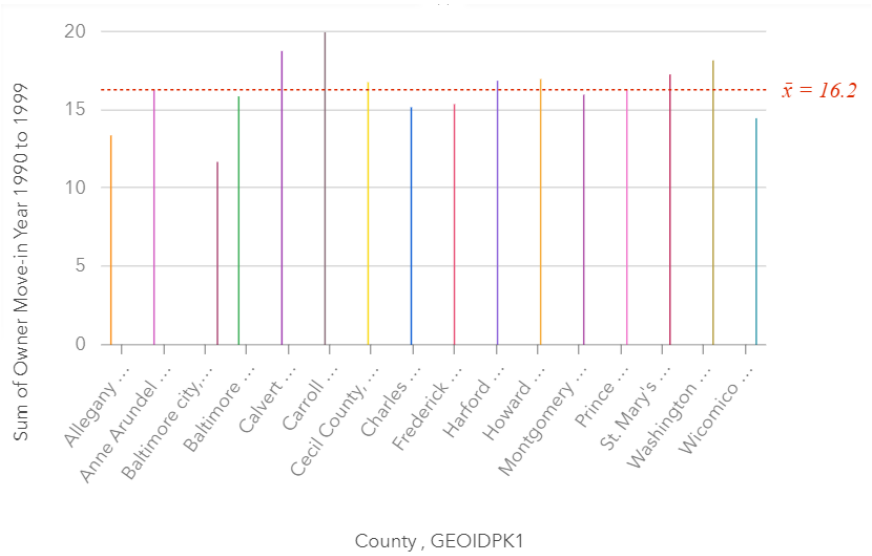
The figure on the left shows the total number of housing units by county. The mean number of housing units per county is 128,691. This information may tell us the more populated counties,

which include Montgomery, Prince George's, Baltimore, Baltimore City, and Anne Arundel Counties, all of which are above the mean.

This information, does not, however, tell us about the *density* of the counties. For that, we would need to also factor in the area.

Figure 2. Total number of housing units by county.

Other Decades



The census data can also give us insight into other decades, such as the 1990s explored in Figure 3. Similar to Figure 2, this data can give us insight into the amount of people living or moving into a county. Here we can see Carroll, Calvert, Washington, St. Mary's, Harford and Howard Counties seeing a high number of owner move-ins in the 1990s.

Figure 3. Owner Move-ins 1990-1999.

Origin-Destination Employment | Itai Tirosh Intrater

Introduction

The DMV area is notorious for its high commuting times and heavy traffic. Many residents commute long hours to get to work, and many who work in DC live in the surrounding counties in Maryland and Virginia. This analysis aims to investigate origin-destination employment and uses various methods to understand where Maryland residents live and commute to work.

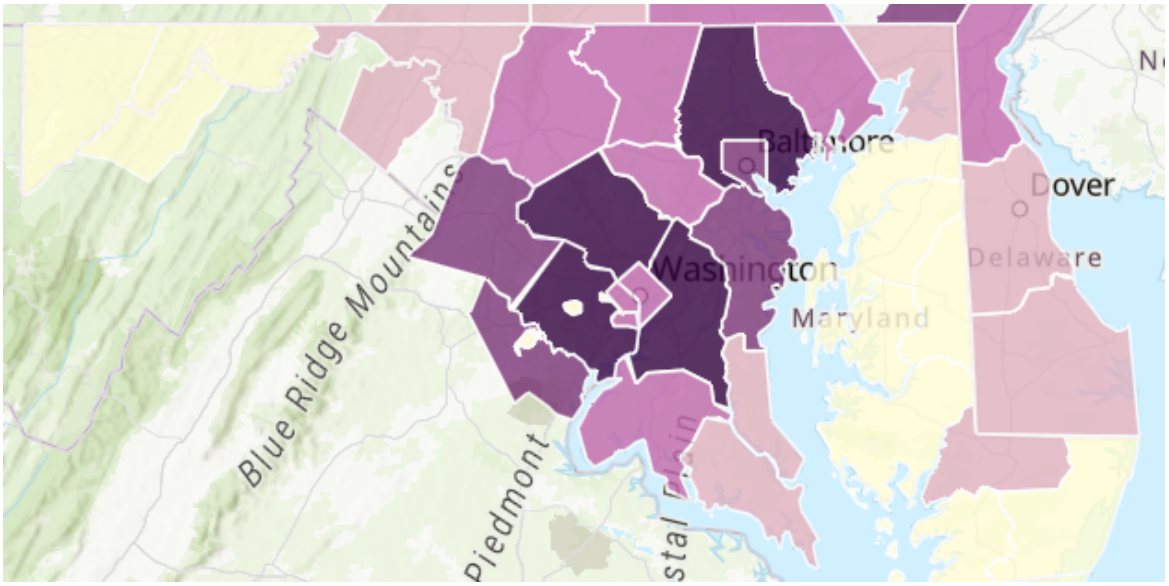


Figure 1. Living in the county but employed outside. Counties with a higher amount of residents working in a different county than their home are darker purple, while lower is shown as lighter yellow.

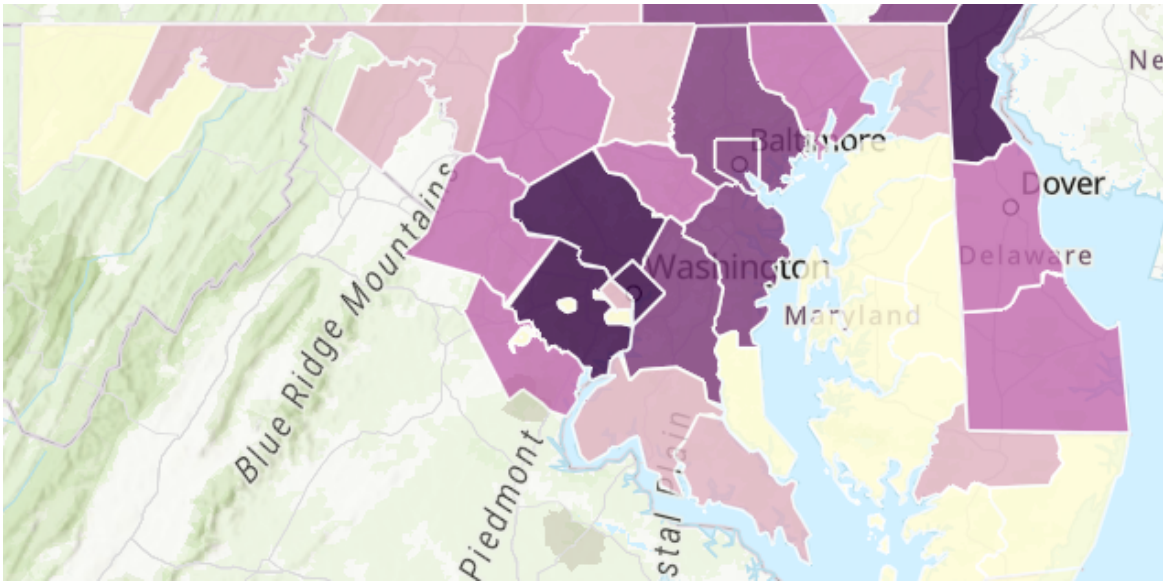


Figure 2. Living and Employed within the county. Counties with higher amounts of people living and working within the county are darker, lower amounts are yellow.

Areal Interpretation

ArcGIS Pro's Geostatistical Wizard was used to do an areal interpolation of the LEHD Origin-Destination Employment Statistics.

Results

Both maps give us similar broad trends. The eastern shore and western panhandle of the state have a lower total number of people living in a county but employed outside, as well as living and employed

within the county. This may be due to their populations generally being lower. In central Maryland, where county populations are higher, we see higher amounts of people both living in a county but working outside of the county, as well as living and employed within one county. Perhaps further analysis could look at the percentage of people within both of these categories for each county, which would allow us to compare the *rates* across counties rather than the raw numbers.

There are some key differences between the two maps. Firstly, more people live in Baltimore County but work outside, than live and work within Baltimore County. This could be due to its proximity to Baltimore City; people with families or other reasons to live outside in the suburbs could be commuting to Baltimore City to work. We see the same pattern happening in Prince George's County. This county is also close to a major city, and perhaps the higher number is due to people living in the county for a number of reasons (lower costs, for example), and commuting into DC for work.

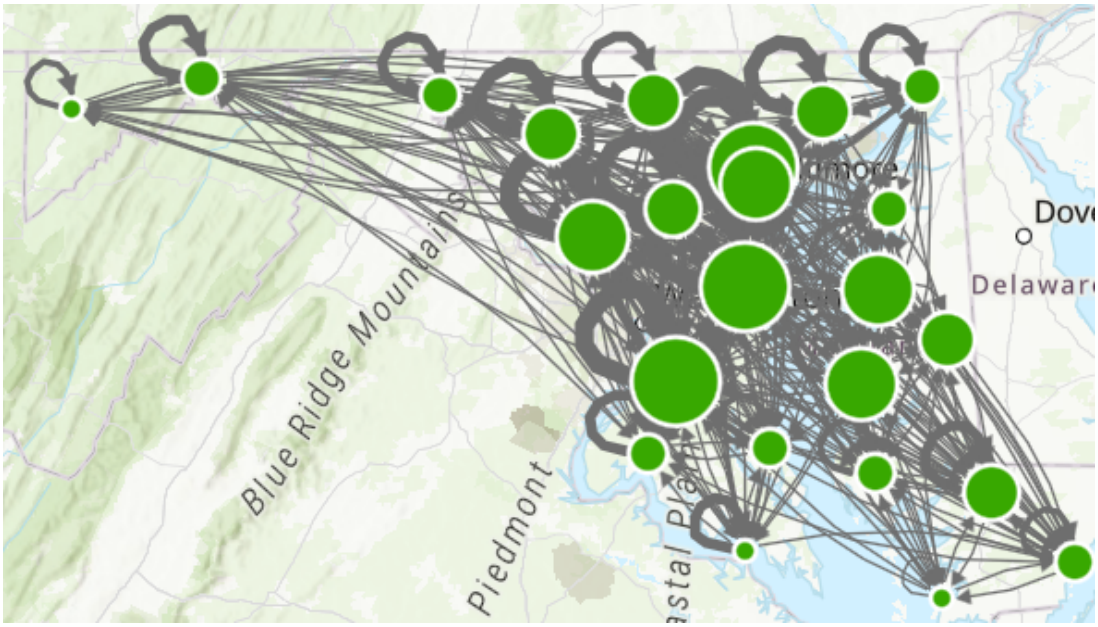


Figure 3. Origin-Destination flows from Maryland Counties to Maryland Counties.

The above figure shows us an origin-destination flow map for Maryland. Though hard to read in a static format, in ArcGIS this map is dynamic, and it's possible to zoom in and out for more detail. We can see the hubs shown as large green circles in the center of the state, with big bubbles around Baltimore and DC.

Pedestrian Sidewalk Safety | Brandon Myron Bush

Introduction

A crucial aspect of managing traffic safety is mitigating the danger to pedestrians. Non-motorists face an increased risk due to the lack of protection that a vehicle provides a driver. Most people have access to some form of motorized transportation that allows them to travel to and from their workplaces, however, the underprivileged don't often have the ability to utilize a motor vehicle, thus making their commutes all

the more arduous. Here, using census data, I take a look at how dangerous a person's commute might be based on their walk times and number of available sidewalks with respect to roadways.

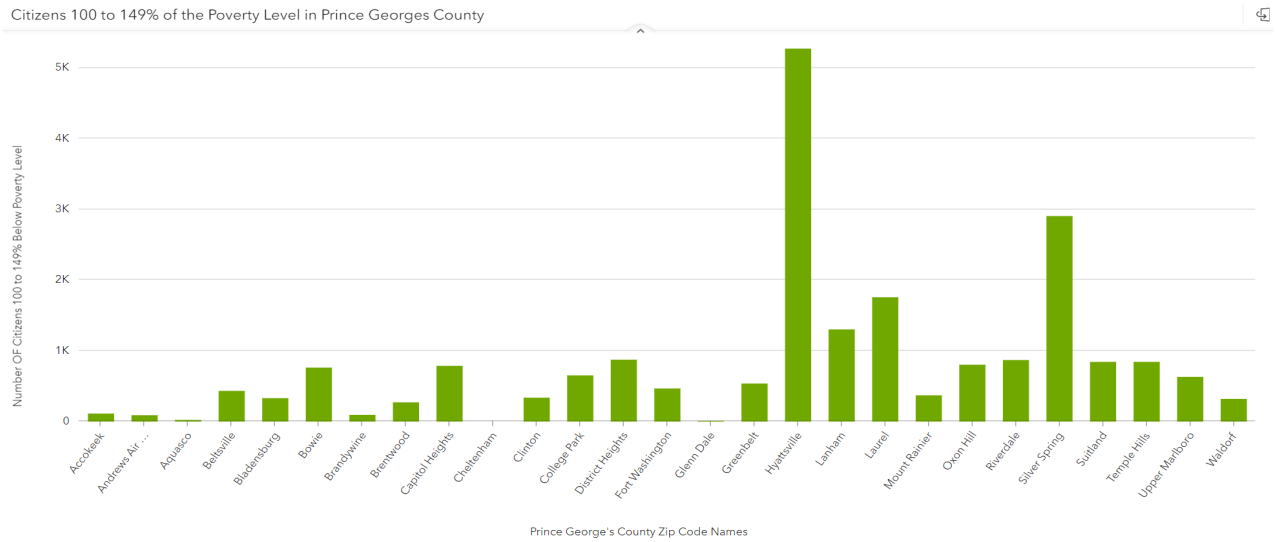


Figure 1. Citizens 100-149% of the poverty level in Prince George's County

The first step was to calculate the % of citizens in poverty that walked to work with respect to the total number of people that were within the 100-149% poverty level in those zip codes.

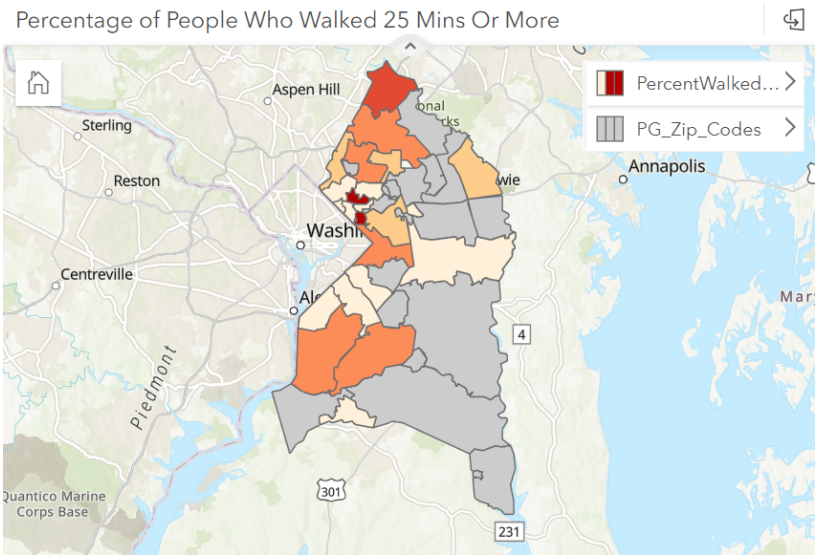


Figure 2. % of people who commuted (walking) 25+ mins.

The next step (Figure 2) was to calculate the percentage of citizens in poverty that walked to work with respect to the total number of people within the 100-149% poverty level in each zip code. Next, I found out which counties had a higher ratio of sidewalks to roadways; the goal was to display which zip codes might have safer walking conditions for pedestrians.

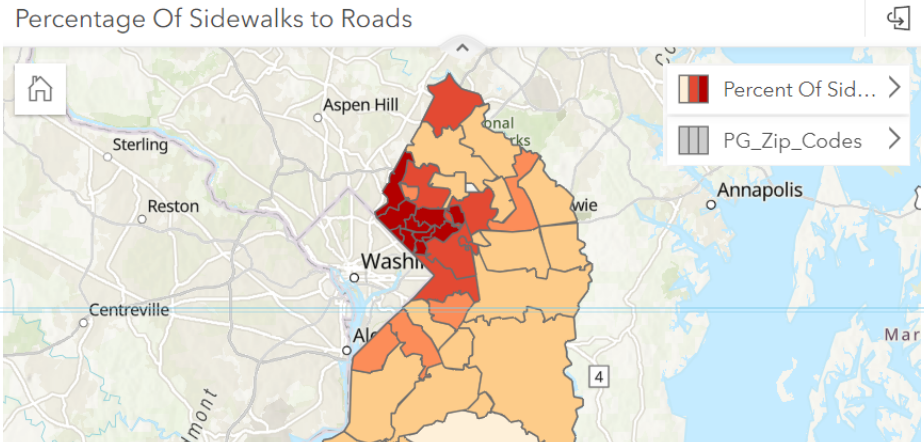


Figure 3. Ratio (%) of Sidewalks to Roads.

An OLS regression on these two variables was conducted to find if the

amount of citizens who walked 25+ minutes was dependent on the ratio of sidewalks. From there a Global Moran's I was done (value: 0.091109) and found that there was significant clustering.

Further analysis could be justified by looking at Maryland Benchmarks for Pedestrian Crashes from the most recent reports from 2019. These contain five-year totals for crashes within the state of Maryland.

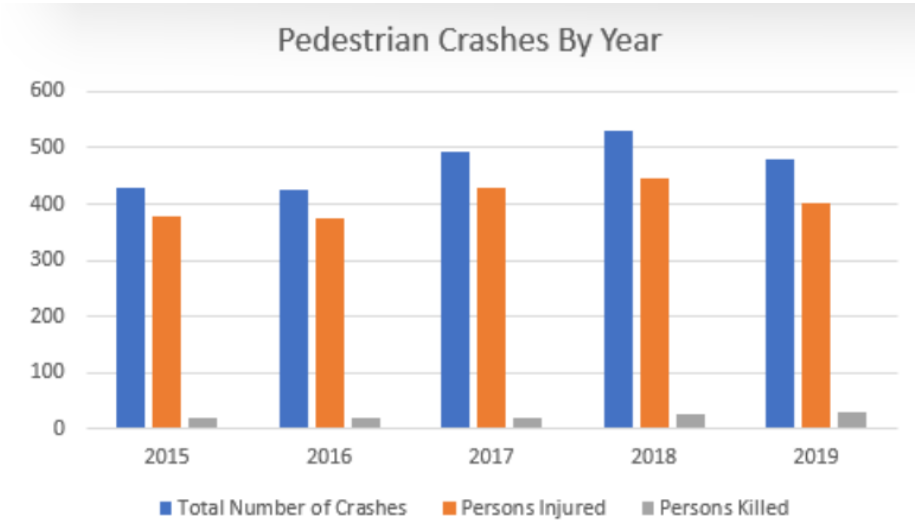


Figure 4. This chart shows pedestrian crashes in Prince George's County for the years 2015-2019. We can see a slight upward trend over this period.

Results

All in all, these findings show that there is a correlation between sidewalk presence and the amount of citizens in each census tract who walk over 25 minutes to work. This could lead to two special insights. On one hand, by identifying the areas where people do walk over 25 minutes to work, the county government may want to invest in more sidewalks, speak to commuters about their experience, or expand public transport in these areas to allow more people to take the bus to work. Also, based on the percentage of sidewalks to roads, the county government could identify locations where there are fewer sidewalks, which tend to be further from DC, and create a plan to expand sidewalk access in these areas. Public transportation and sidewalk access are key to giving people a safe, affordable, and more environmentally friendly commuting option. Good data can help plan for improved access to cheaper transportation.

Electric Vehicle Chargers and Income | Angela Scafidi

Introduction

The US is on the brink of a massive shift in the vehicle market towards electric vehicles (EV), and government support is helping reduce the costs of the vehicles themselves as well as increasing the amount of charging stations around the country. EVs are still incredibly expensive, so this analysis aims to look at two variables, median income and EV charging stations, in Maryland and determine if there are patterns and any correlations between the two.

Methods

- EV Charging stations (point data): nearest neighbor, Kernel density, and hot spot analysis
- Residential Charging Stations: Moran's I, General G

- Median Household Income per zip code: Moran's I, General G, hot spot analysis

EV Charging Stations (Non-residential) locations and Mean Center

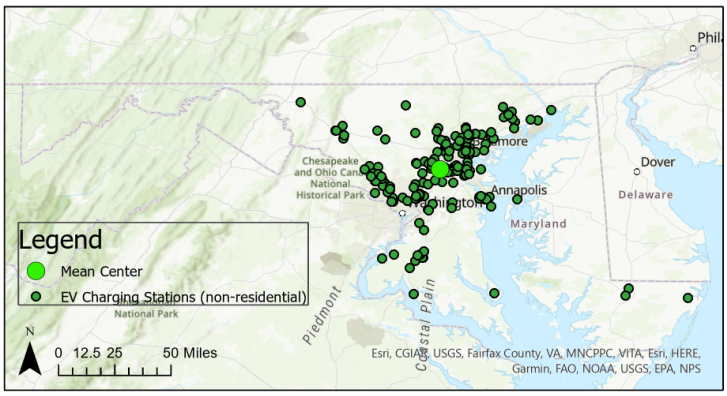


Figure 1. EV charging stations are mostly located I central Maryland, which makes sense as it has a higher population and more commuters to Baltimore and DC. Kernel density analysis showed similar results.

The majority of those who took advantage of the state rebate program for installing residential EV chargers were also in central Maryland.

Hot and Cold Spot Analysis of MEA Contributions to EV Charging Stations (non-residential)

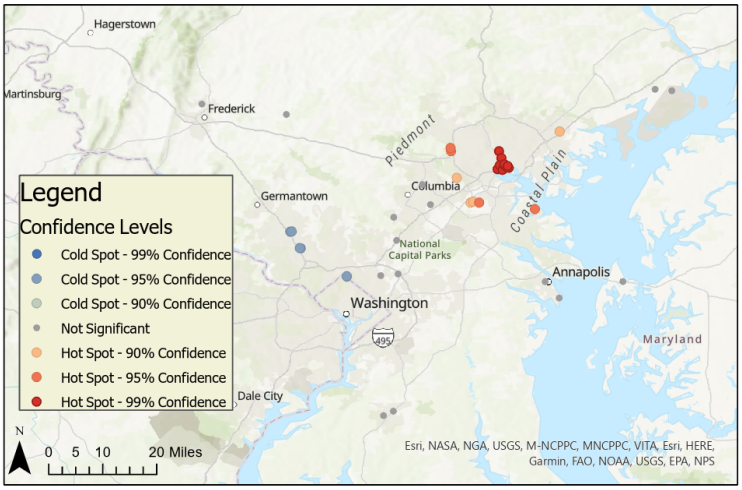


Figure 2. Hot and Cold Spot Analysis of MEA contributions to non-residential EV charging stations. As you can see, there's a cluster of hot spots (high governmental contributions) to chargers in Baltimore, and a cold spot in the western suburbs of DC.

Perhaps in the DC area there is strong local funding for EVs, so they wouldn't need state funding, or businesses in those areas had the resources to establish their own charging stations in parking lots without governmental support. Looking at Baltimore City, we see it's a cold spot for income (Figure 3), though there is a high number of EV chargers. When we look closely at the locations of the charging stations, we see many of them are located in the 'white L' of the city, which has higher income and a higher white population.

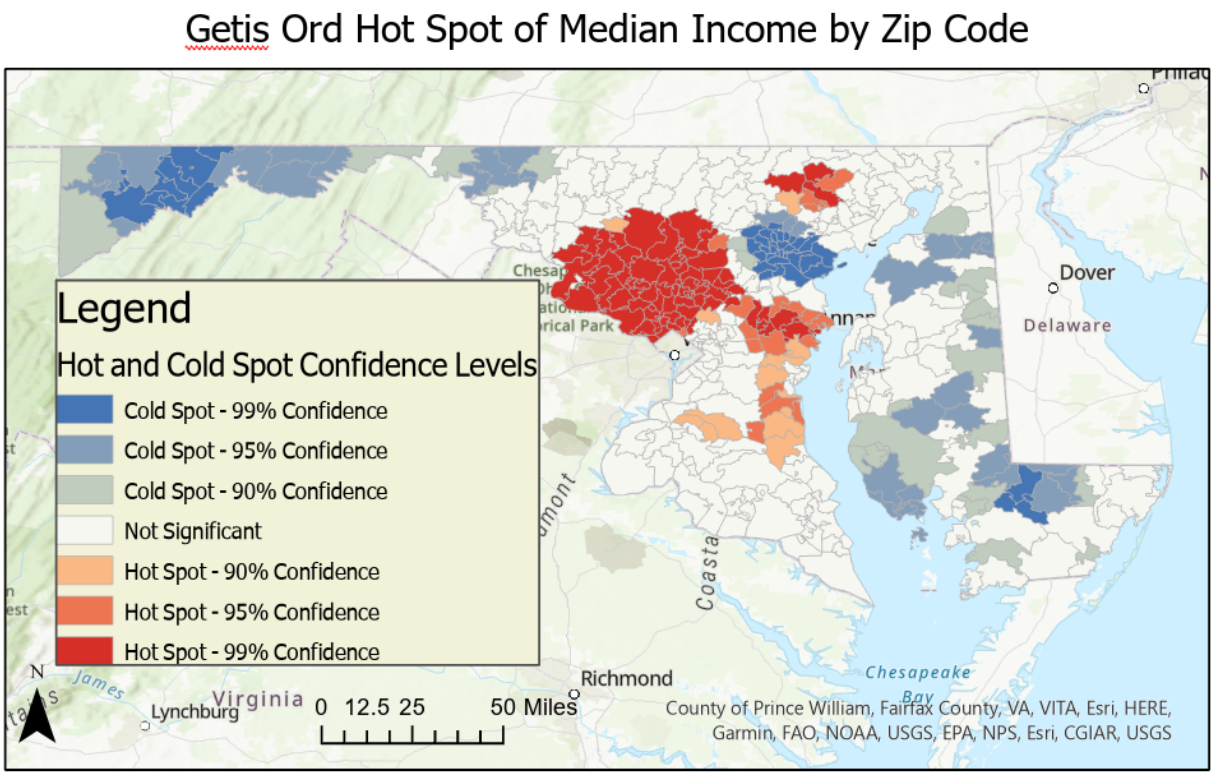


Figure 3. Getis Ord Hot Spot Analysis of Median Income by Zip Code.

Findings

Broadly, the hotspots of the wealthier region in Maryland coincide with the hotspots of charging stations. In particular, the western suburbs of DC stretching towards the middle are high income hot spots. These areas are predominantly in Howard and Montgomery Counties. In addition, we see that the opposite is true; lower income areas do not have many charging stations. The western panhandle has no charging stations or residential rebates, and the eastern Chesapeake Shore has very few. While income may not be the cause, as these two regions are both very rural and agricultural and not as population dense, income and charging stations are certainly correlated.

Conclusion

Governments have set 'green' targets under the Paris Climate Agreement, and in practice, many are turning to EVs as one solution to the transportation emissions issue. One of the major barriers to the adoption of EVs, however, is the higher cost (Carrington). However, estimates show that EV prices will be able to compete with other vehicles in just a few years, and this shift will need to coincide with more equitable placement of EV charging stations. This assessment shows that currently EV charging stations generally coincide with areas of higher income. Ensuring that charging stations, obviously as well as EVs, are accessible to *all* is imperative to their widespread adoption. Finally, EVs should not be seen as a panacea to the climate crisis and should rather be used to supplement the change to an affordable and expansive public transportation system.