Spatial Statistics Studies
for the Maryland Department of Planning

Brandon Myron Bush, Itai Tirosh Intrater, Peter Jablonski, Karl Joseph Logan,
Ryan James McWeeny, Blake Weimann Munshell, Luc Benjamin Renaux, Angela Isabella Scafidi

Under the supervision of
Professor Rejanne Katell Le Bivic

GEOG651: Spatial Statistics
University of Maryland – College Park
Winter 2022

PALS - Partnership for Action Learning in Sustainability
An initiative of the National Center for Smart Growth

Gerrit Knaap, NCSG Executive Director
Kimberly Fisher, PALS Director

Table of Contents

Introduction

The following investigations are from students' final projects in 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. The Maryland Department of Planning does not approve or endorse these analyses.

This project was a first experience for many of our students in using census data. Because students themselves chose the questions to investigate using census data, there is a variety of topics in these projects.

Demographic Projects

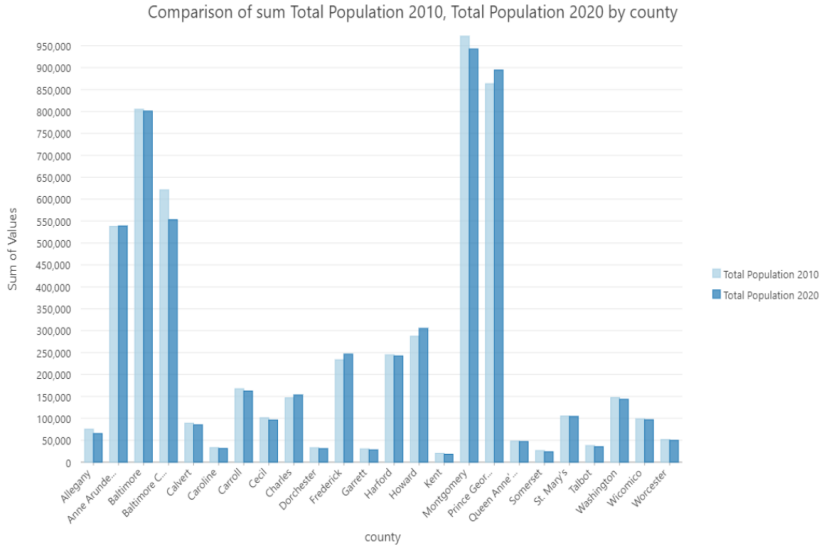
Demographic Change 2010-2020

Introduction

Between 2010 and 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 U.S. Census Bureau and provided by the Maryland Department of Planning.



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%.

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

We can look at this population change in Figure 1, which shows the difference in absolute numbers or by percent change in Figure 2.

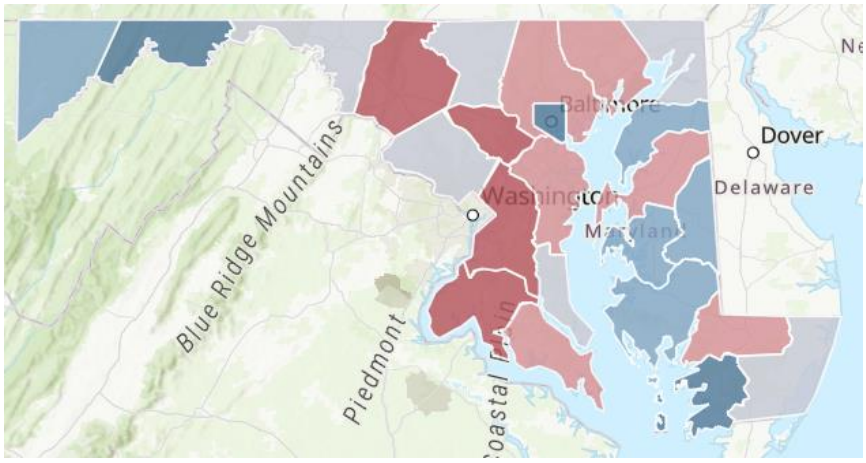
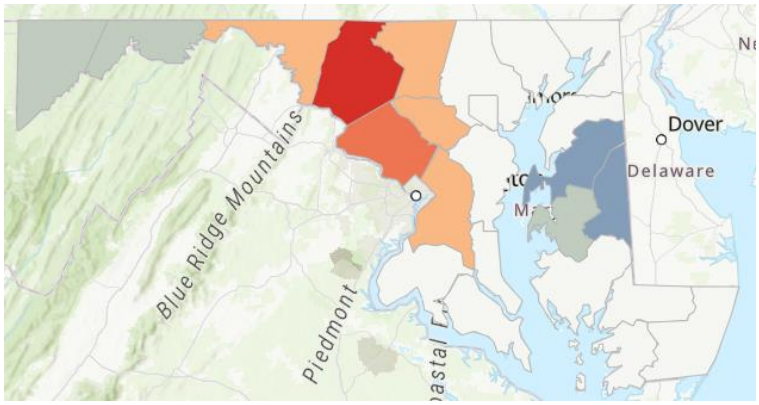


Figure 2. Percentage population change in each county

Black Populations

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



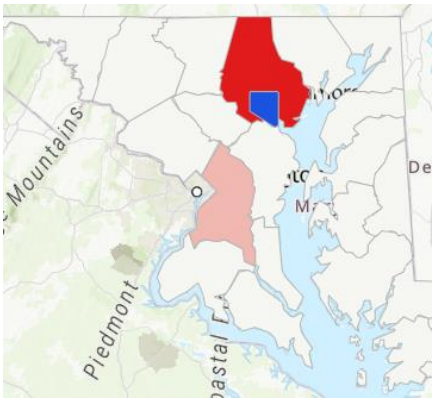


Figure 3. Cluster and Outlier analysis of change in black population

White Populations

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

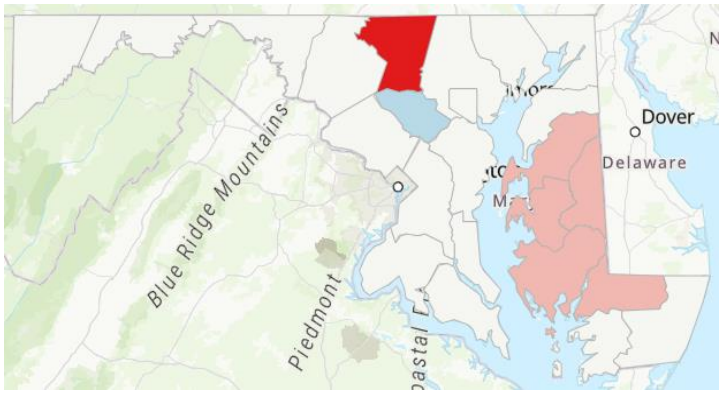


Figure 4. Cluster and Outlier analysis of change in white population

Asian Populations

The analysis showed no significant outliers for growth in 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, Baltimore County, and Frederick County are hot spots for high growth rates 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 analyses on Indigenous populations show that Kent County is part of a region undergoing a decrease in Indigenous populations. By contrast, 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

Introduction

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

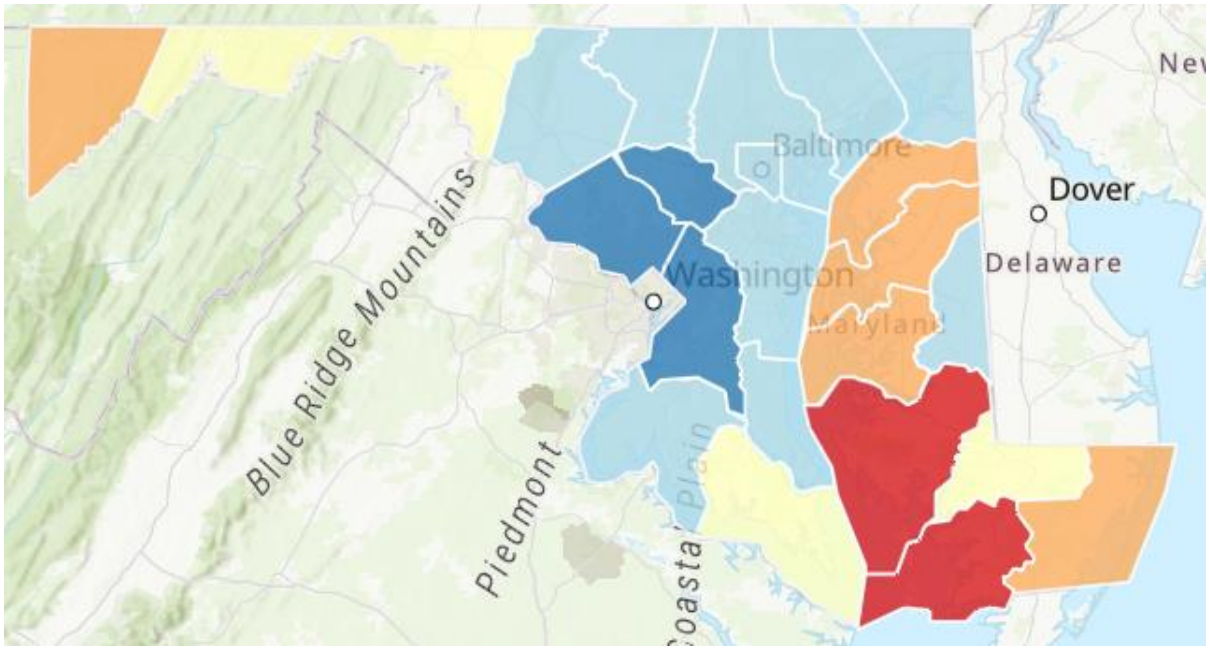


Figure 5. Ethnic diversity by county

Goals and Data

This report is an analytical tool for exploratory analysis of ethnic diversity at various scales in 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 5 shows ethnic diversity by county, while Figures 6 and 7 show ethnic diversity by census block. Scale is a major factor in any census data research. The county level map (Figure 5) is more clear, identifiable, and gives a good broad overview of Maryland regions that are more and less diverse. On the other hand, it may miss nuance seen at the more granular census tract map scale (Figures 6 and 7).

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.

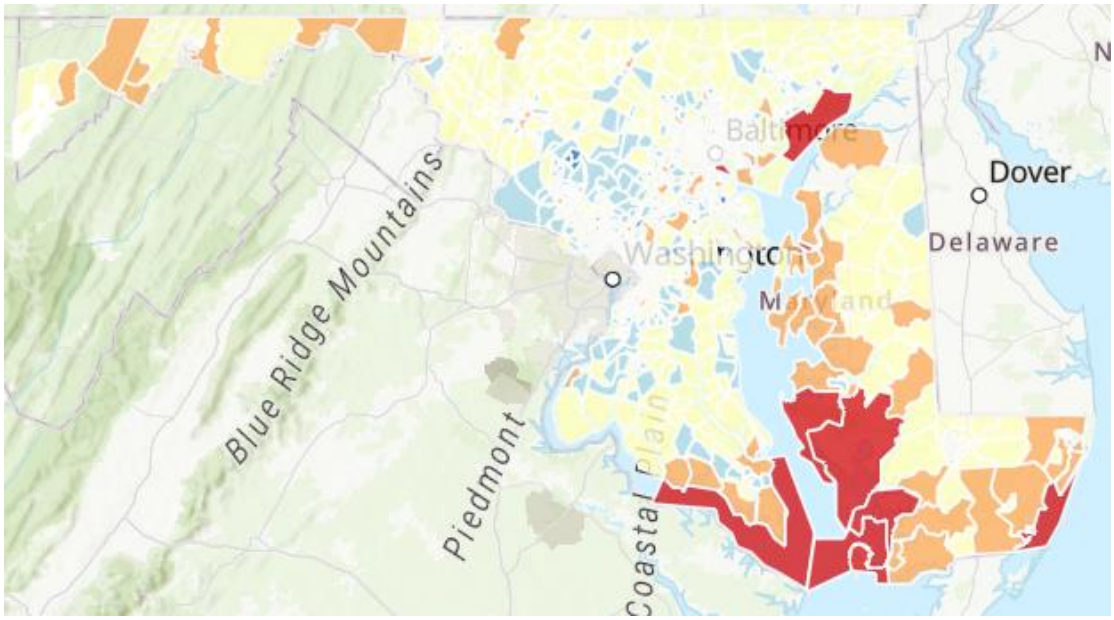


Figure 6. Statewide ethnic diversity by census block

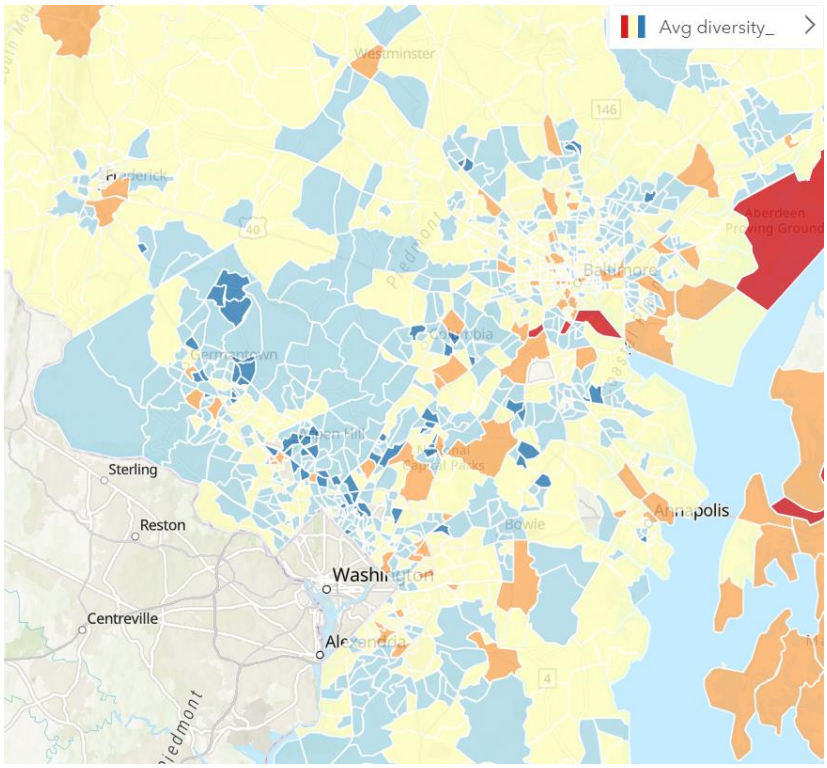


Figure 7. Ethnic diversity by census block in central Maryland

Results

Both maps show that in general, Maryland's Eastern Shore and western panhandle are less diverse, while central Maryland is more diverse. The county-level map (Figure 6) shows that Howard, Montgomery, and Prince George's Counties are the most diverse. This pattern is held up in the map of census tract data (Figure 3), which shows large amounts of blue (more diverse) areas.

The more detailed census tract data shows which locations within the diverse counties (Howard, Montgomery and Prince George's) are most ethnically diverse. Census tract data shows more details and variations within each county. However, Figure 6 is difficult to interpret quickly, and the county map has an advantage if the viewer's goal is to understand general trends rather than granular details.

Maryland Race, Income, and Climate Change Risk

Introduction

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

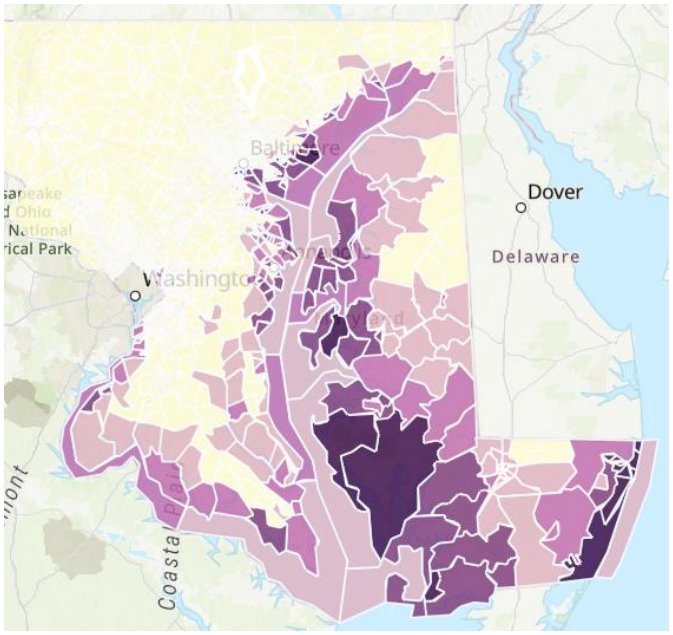
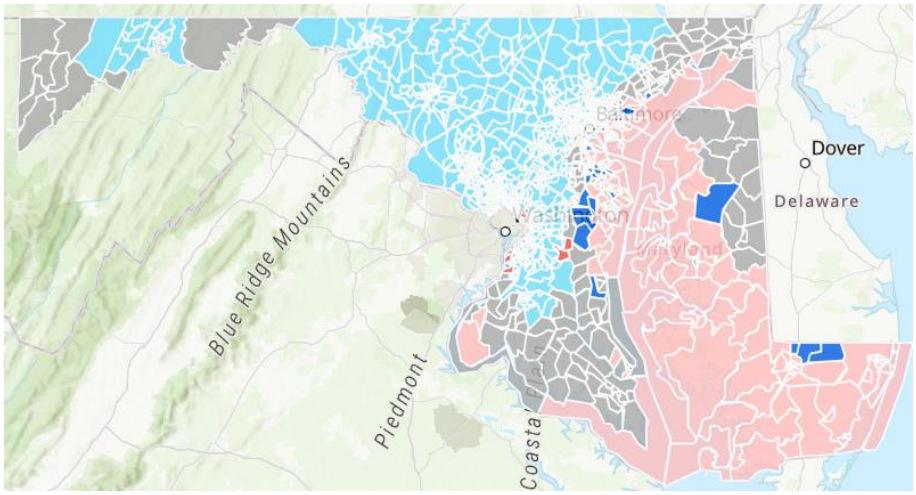


Figure 8. Calculated risk for adverse effects of climate change

Methodology

ACS data 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.

A spatial autocorrelation determined whether and where the data was clustered. Exploratory analysis and regression were conducted to assess correlations.



Risk Calculation

Risk was calculated by applying an average risk based on five datasets that included a digital elevation model, two MDOT critical area layers, and land cover information. A Moran's I shows that the risk of adverse effects from increased sea level rise is significantly clustered.

Figure 9. Local Moran's I Cluster/Outlier risk of sea level rise

A Local Moran's I Cluster/Outlier analysis (Figure 9) shows that shore areas have clusters of high-high values, which makes sense as these areas are on the water. There are also a few pockets of high-risk areas along the Potomac near DC that are surrounded by low-risk tracts.

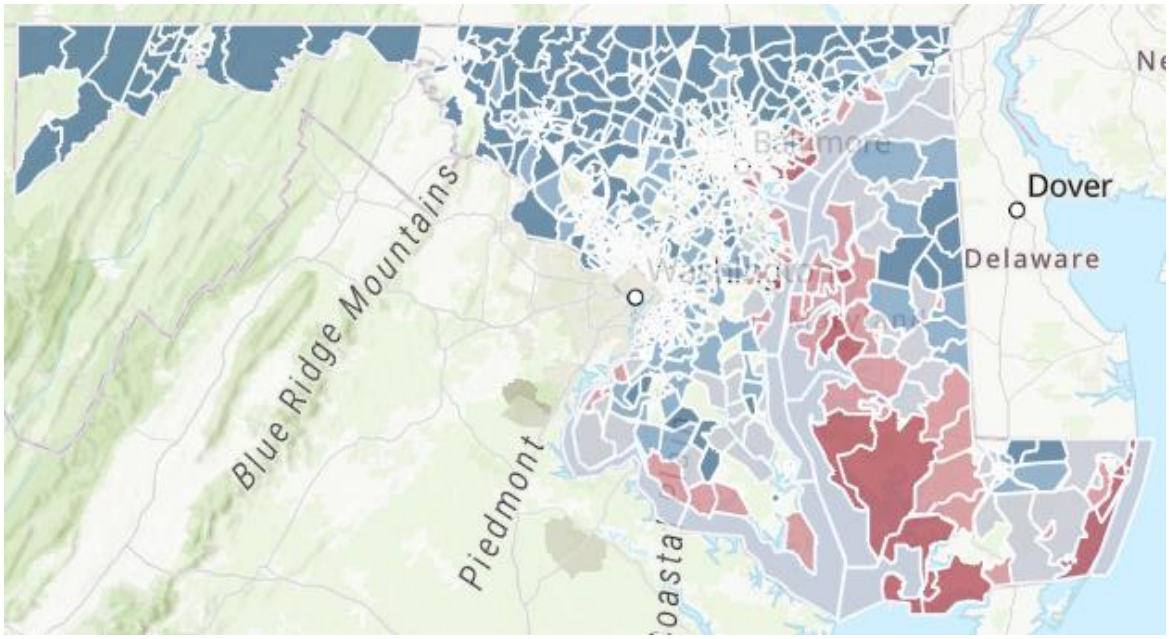


Figure 10. OLS Standard Residuals using populations in poverty

	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

Figure 11. Risk and correlation

Correlation with Race and Income

Likely due to the large number of very low risk tracts, there are no immediately visible correlation trends between income, race, and risk. Some factors explain this, including that poorer and majority-minority populations tend to live outside of DC and Baltimore, not on the Eastern Shore. However, removing tracts where risk is 0 and thereby assessing the demographics of regions with some risk, shows more of a correlation. Nevertheless, in both cases there is a very low coefficient of determination and slope associated.

Conclusion

This study attempted to parse this data and assess unequal effects from sea level rise due to climate change. But it's difficult to assess race and risk in Maryland because the state has pockets of high minority populations, pockets of majority-white regions, as well as pockets of extreme poverty, despite being the richest state in the country.

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 considerable, that rate is accelerating, so the need for mitigation is greater than ever. Floods in Maryland have already caused great damages to livelihoods, with significant property damage, loss of life, and decreased tourism.

Housing Related Projects

Vacant Housing in Maryland: 2010

Introduction

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

Methodology and Results

The first step was to join housing data to census tracts, then to calculate the percentage of vacant homes in order to compare tracts. Spatial autocorrelation tests were performed on these data for the rest of this study.

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.

Figure 12. Spatial autocorrelation report (Global Moran's I)

The first test, the Global Moran's I, can show if there is a spatial autocorrelation. The test indicated that vacancy percentages were clustered with a very high confidence (Figure 12). To determine where the clusters and hotspots are within the tracts, more tests are required.

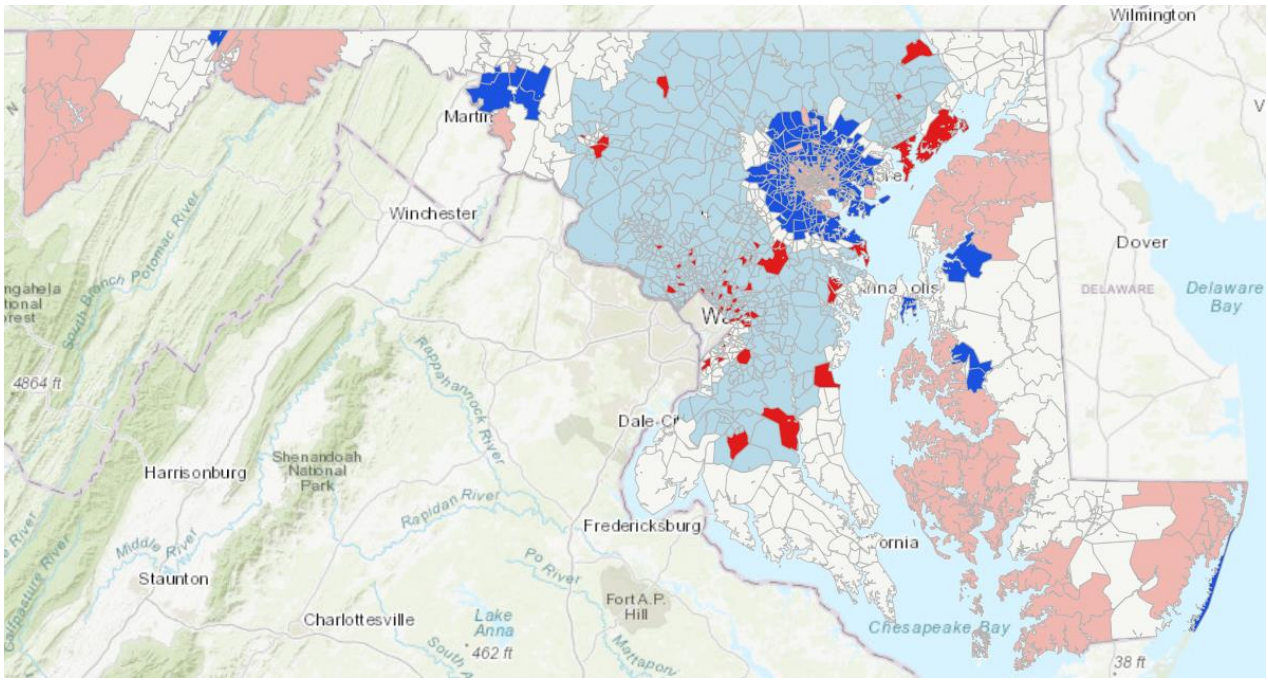


Figure 13. Vacant housing percentage clusters and outliers (Local Moran's I)

The results show a cluster of low-vacancy housing forming an S-shape through the middle of the state, and high-vacancy clusters in the rural east and west as well as the City of Baltimore (Figure 13). A ring of outliers in Baltimore County surrounds the City, indicating a lower percentage of housing vacancies than in the City. This makes sense as Baltimore has seen a population decline. Smaller negative and positive outliers are scattered throughout the state, likely the result of smaller population shifts.

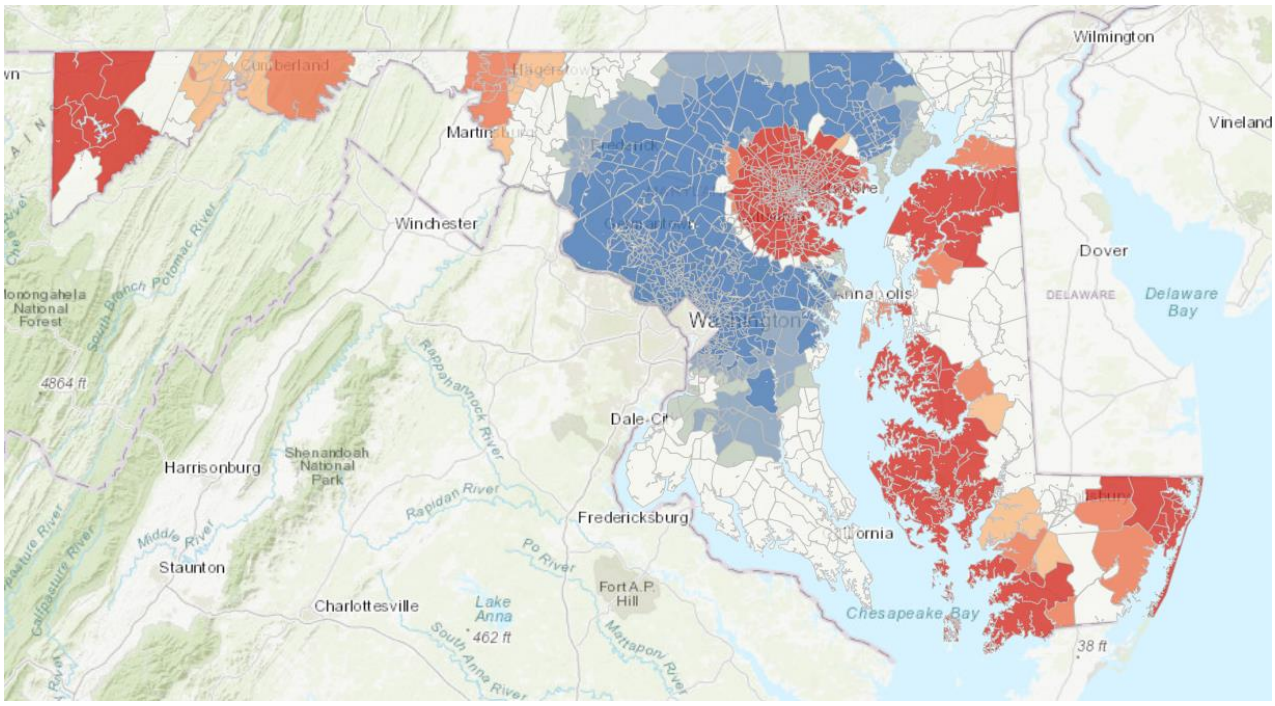


Figure 14. Vacant housing percentage hot and cold spots (Local Getis-Ord G Statistic)

This analysis is consistent 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 (Figure 14).

Conclusion

The results of this study support the original hypothesis. The Global Moran's I test indicated a spatial autocorrelation among the percentage of vacancy values of the 2010 Maryland census tracts. The results of the Local Moran's I test located high-high and low-low clusters in predicted locations: the City of Baltimore and rural east and west for high-high and middle suburbs for low-low. Lastly, the Getis-Ord hot spot analysis further confirmed the locations of the predicted hot spots and cold spots.

These results could be due to population changes, as eastern and western Maryland's rural areas and the City of Baltimore have been dealing with population loss to suburbs. Further studies could concentrate on areas such as Baltimore City, where the inclusion of statewide data might muddle smaller local trends.

Home Ownership in Maryland

Introduction

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

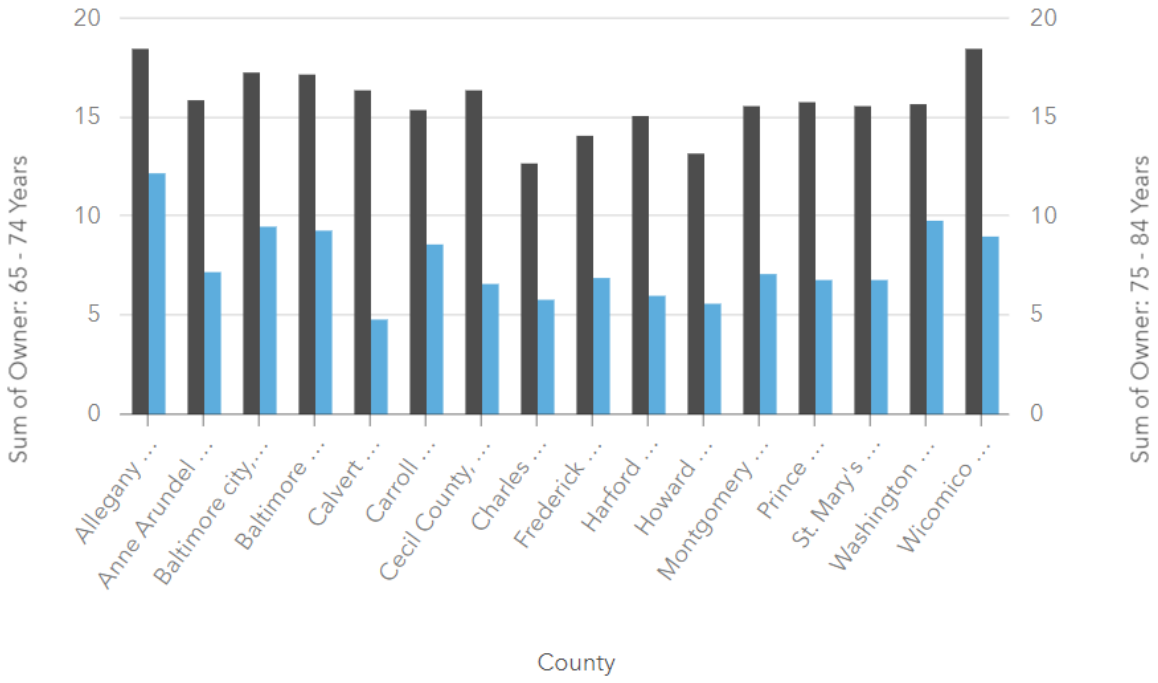


Figure 15. Homeowners 65-74 years old vs Homeowners 75-84 years old

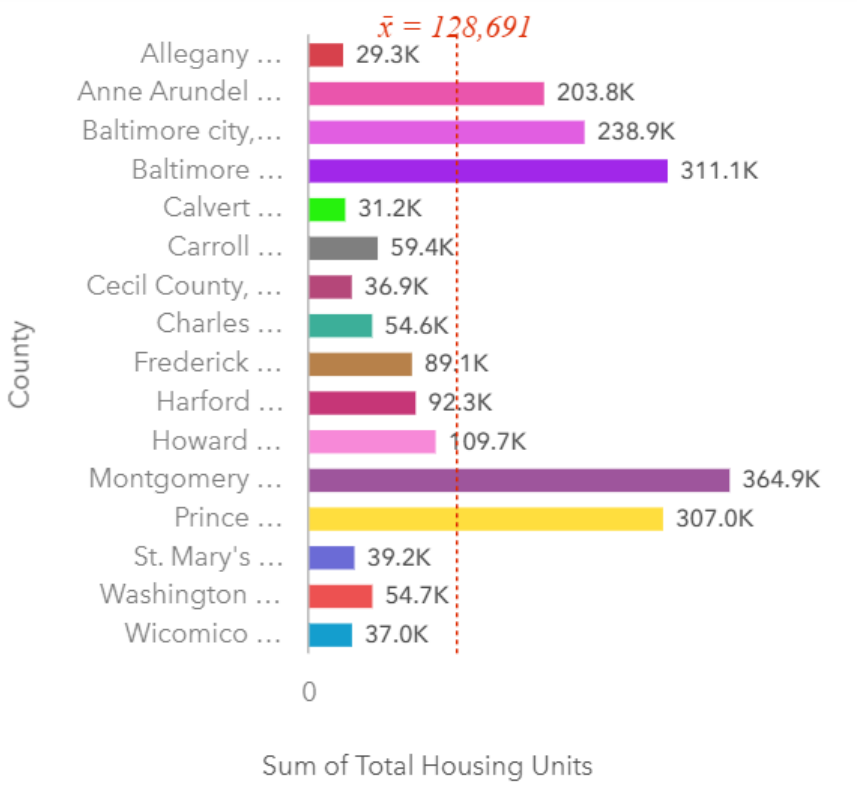
Age

Figure 15 shows each Maryland county and the age of homeowners in each. 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 the fact that older people might need to reside in special care homes as their health declines, or that people may choose to downsize when their children establish their own households.

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 examine generational differences in the costs or ability to own a home, which has become more difficult over the past decades.

Housing Units

Figure 16 shows the total number of housing units by county. The mean number of housing units per county is 128,691. This information shows the more populated counties: Montgomery, Prince George's, Baltimore, Baltimore City, and Anne Arundel, all of which are above the mean.



This information, does not, however, tell us about housing density. For that, we would need to factor in the land area.

Figure 16. Total number of housing units by county

Other Decades

The census data can also give us insight into other decades, such as the 1990s in Figure 17. Like Figure 16, this data gives insight into the amount of people living in or moving into a county. Here we see Carroll, Calvert, Washington, St. Mary's, Harford and Howard Counties experiencing a high number of owner move-ins in the 1990s.

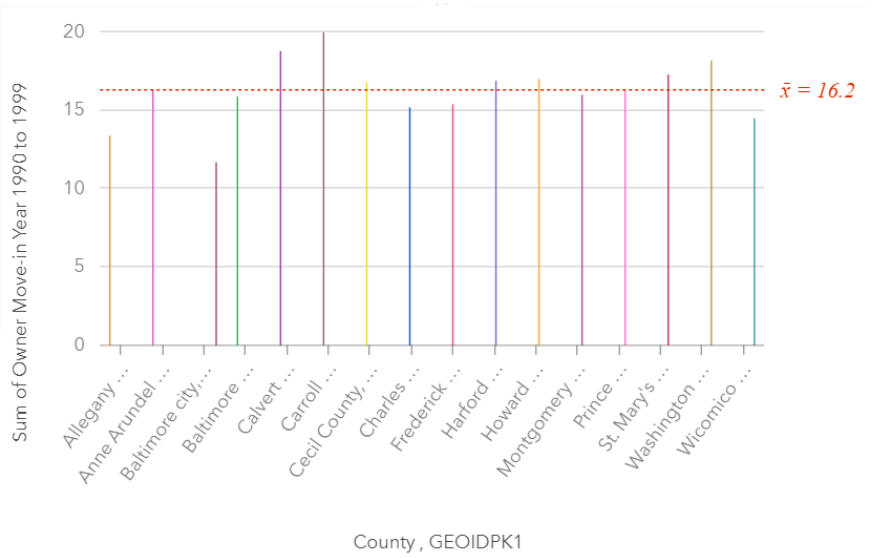


Figure 17. Owner move-ins by county, 1990-1999

Transportation Projects

Origin-Destination Employment

Introduction

The national capital region 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 surrounding Maryland and Virginia counties. This analysis aims to investigate origin-destination employment using various methods to understand where Maryland residents live and commute to work.

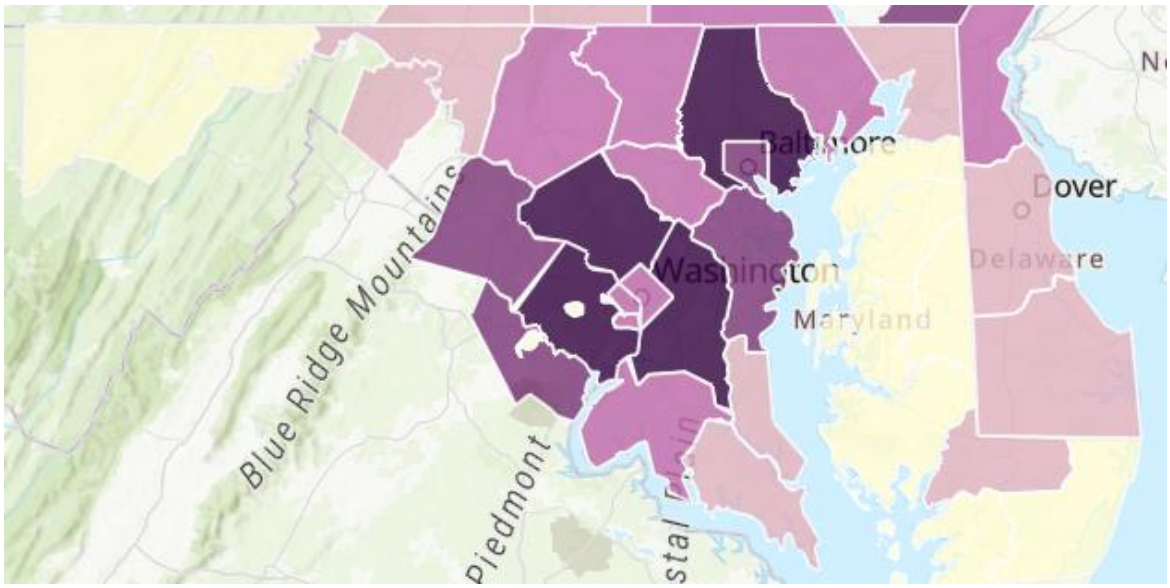


Figure 18. Living in a county but employed outside it. Counties with a higher number of residents working in a different county than their home are darker purple, while lower is shown as lighter yellow.

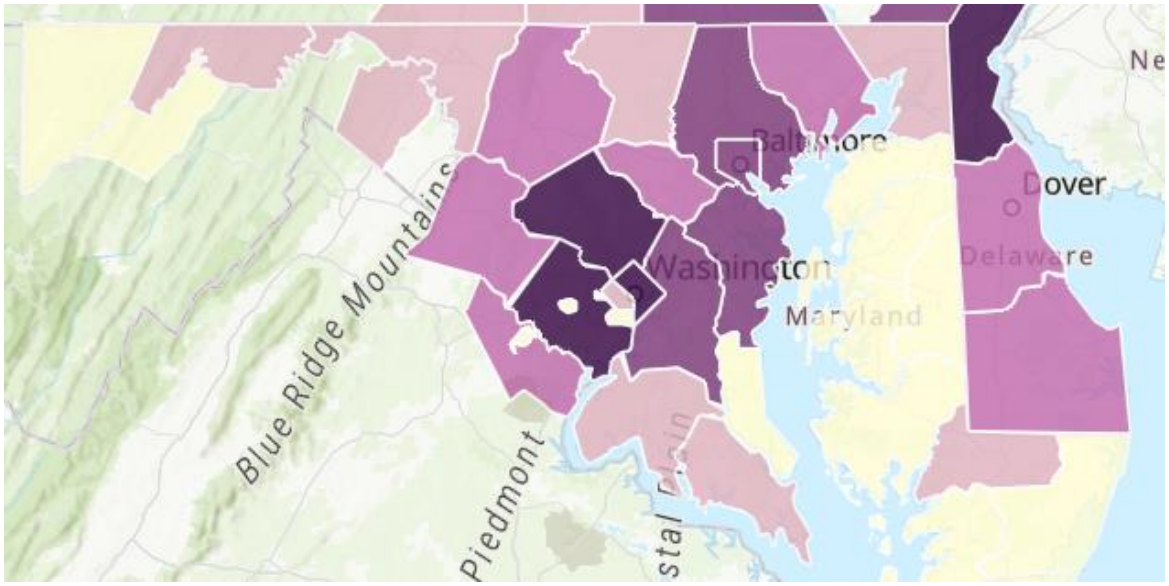


Figure 19. Living and employed within a county. Counties with a higher number of residents living and working within the county are darker, lower amounts are yellow.

Areal Interpretation

ArcGIS Pro's Geostatistical Wizard was used to do an areal interpolation of the LEHD Origin-Destination Employment Statistics, a process that allows data analysis across places of different scales.

Results

Both maps show similar broad trends. Maryland's Eastern Shore and western panhandle both have a lower number of people who live in one county but work in anther, as well as people who live and work within a county. Populations in these areas are generally lower.

In central Maryland, where county populations are higher, higher numbers of people live in one county but work in another, as well as live and work within one county. Further analysis could examine the percentage of people in both categories for each county, which would allow a comparison of the rates across counties rather than the raw numbers.

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

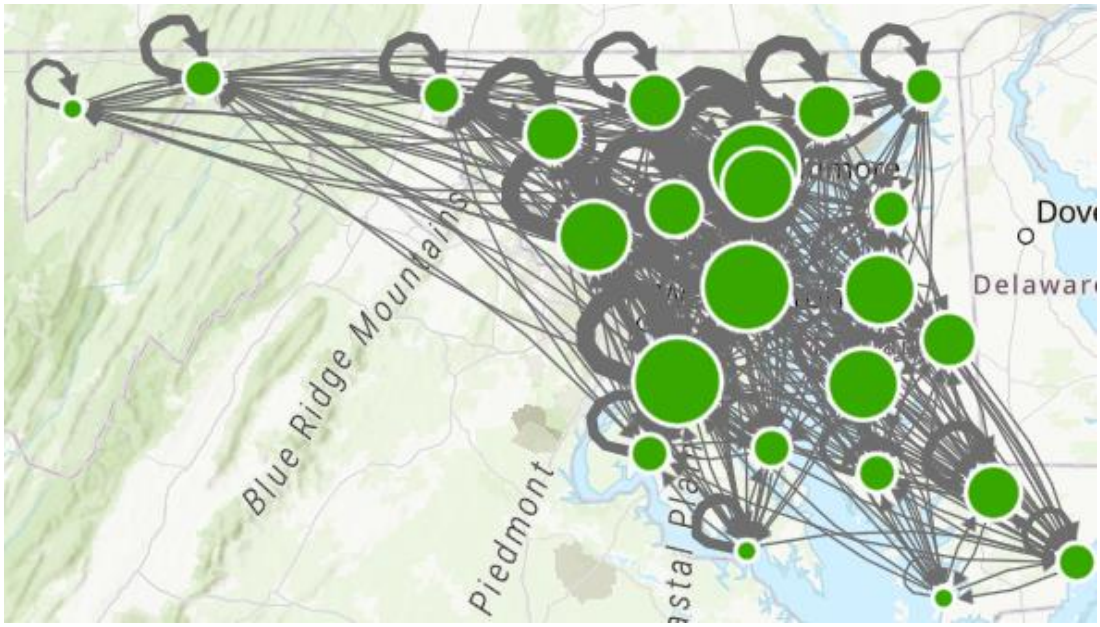


Figure 20. Origin-Destination flows between Maryland counties

Figure 20 shows 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. Employment hubs are shown as green circles—largest in the center of the state, with job concentrations around Baltimore and DC.

Pedestrian Sidewalk Safety

Introduction

A crucial aspect of managing traffic safety is mitigating the danger to pedestrians. Non-motorists face increased risks due to their lack of protection, unlike a driver protected in their vehicle. Many people have access to motorized transportation for commutes; however, others can't use a motor vehicle, making their commutes more arduous. This study uses census data to examine how dangerous a commute might be based on walk times and the number of available sidewalks with respect to roadways.

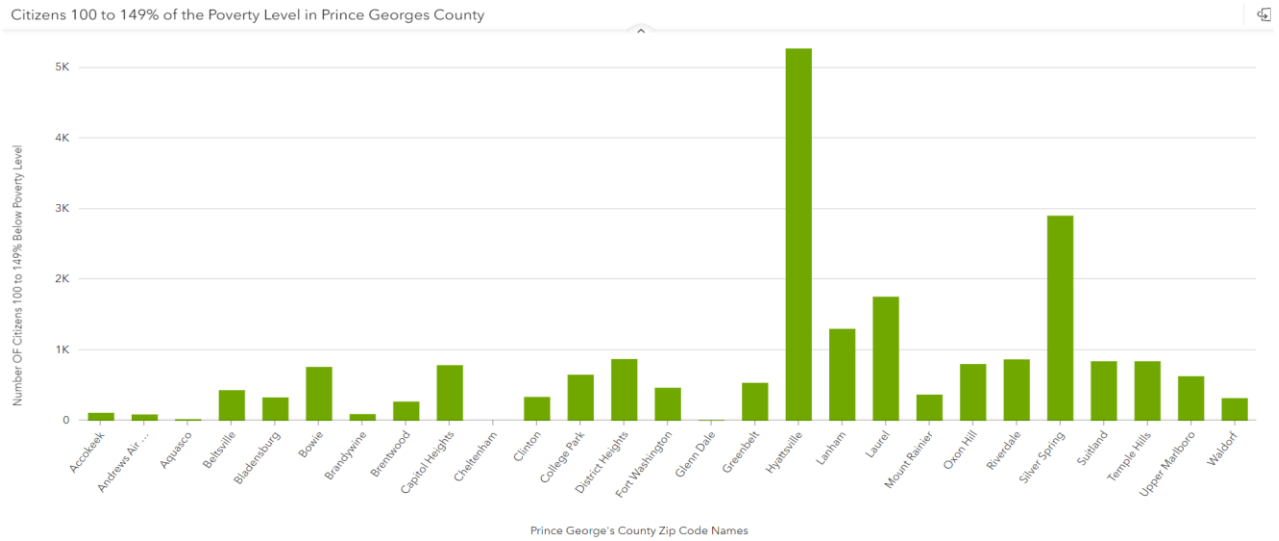


Figure 21**.** Prince George's County residents living at 100% to 149% of the poverty level

The first step was to calculate the percent of Prince George's County residents living in poverty who walked to work with respect to the total number of people that were within the 100% to 149% poverty level in those zip codes (Figure 21).

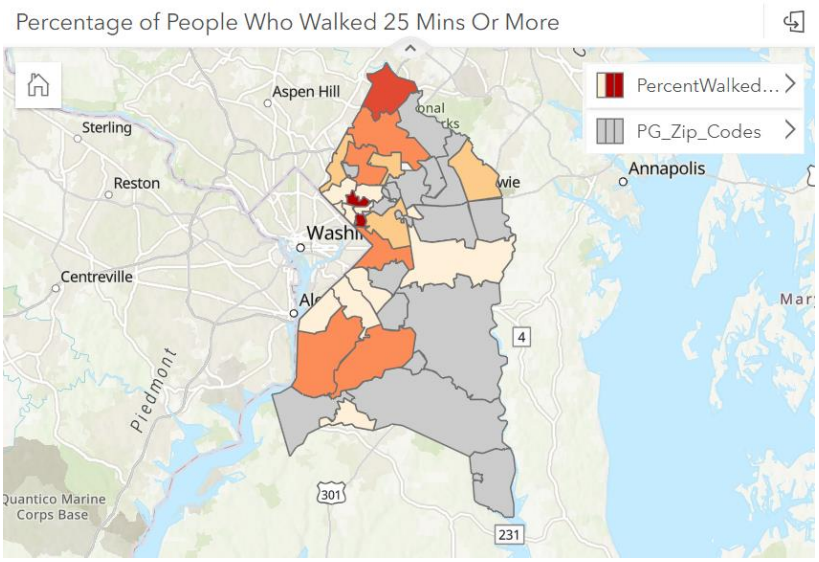
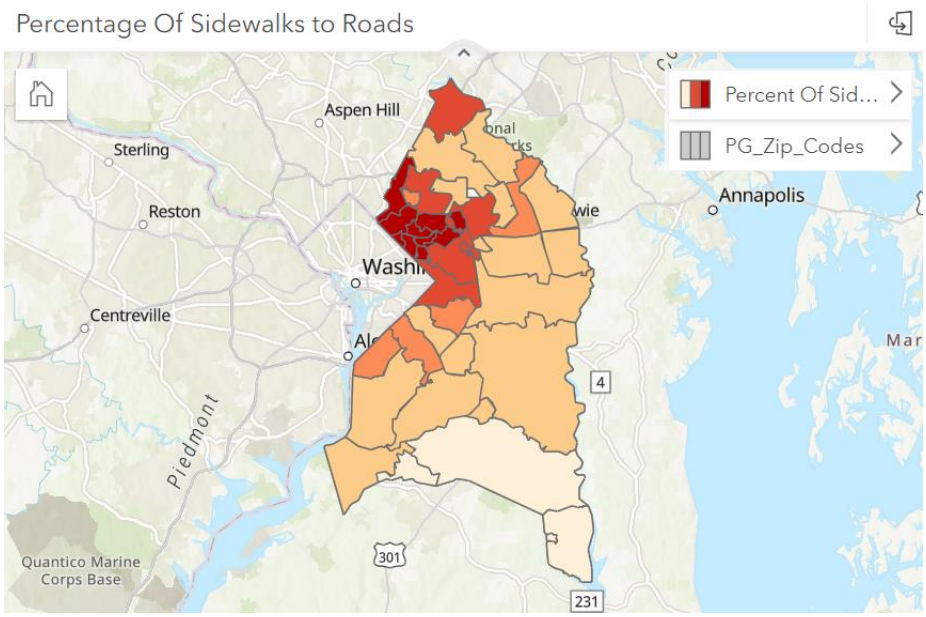


Figure 22. Percent of people who commuted by walking 25 or more minutes

The next step was to calculate the percentage of citizens in poverty who walked to work with respect to the total number of people at the 100% to 149% poverty level in each zip code (Figure 22).

By determining which counties have a higher ratio of sidewalks to roadways could indicate which zip codes might have safer walking conditions.



An OLS regression on these two variables was conducted to find if the number of citizens who walked 25 or more minutes was dependent on the ratio of sidewalks. A Global Moran's I (value: 0.091109) found significant clustering.

Figure 23. Ratio (percent) of sidewalks to roads

Further analysis could look at the 2019 Maryland Benchmarks for Pedestrian Crashes reports. These contain five-year totals for crashes in Maryland.

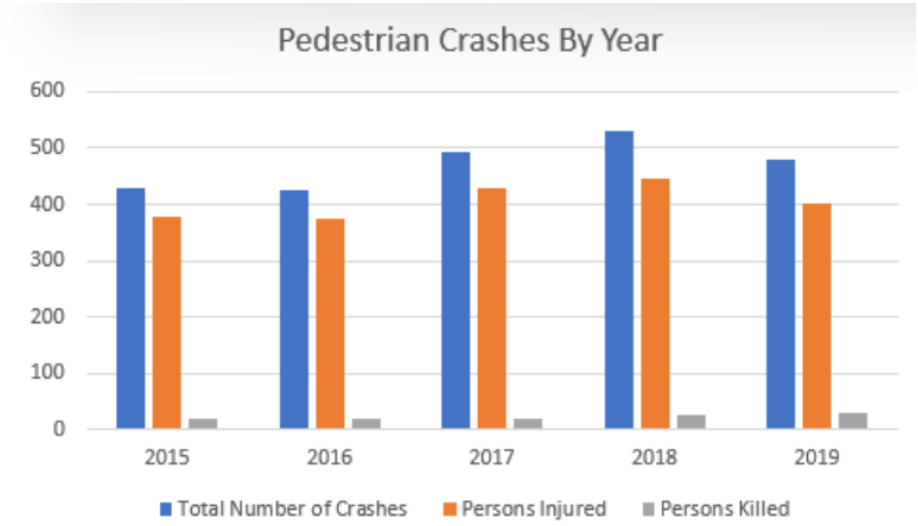


Figure 24. This chart shows pedestrian crashes in Prince George's County between 2015 and 2019. It shows a slight upward trend during this period.

Results

These findings show a correlation between sidewalk presence and the number of residents in each census tract who walk 25 or more minutes to work. This could lead to two insights. By identifying areas where people walk over 25 or more minutes to work, the county could invest in sidewalks, speak to commuters about their experience, and expand transit. Also, based on the percentage of sidewalks to roads, the county could identify locations with fewer sidewalks, which tend to be further from DC, and create a plan to expand sidewalk access in these areas.

Transit and sidewalk access are key to creating safe, affordable, and more environmentally friendly commuting options. Good data can help plan for improved access to cheaper transportation.

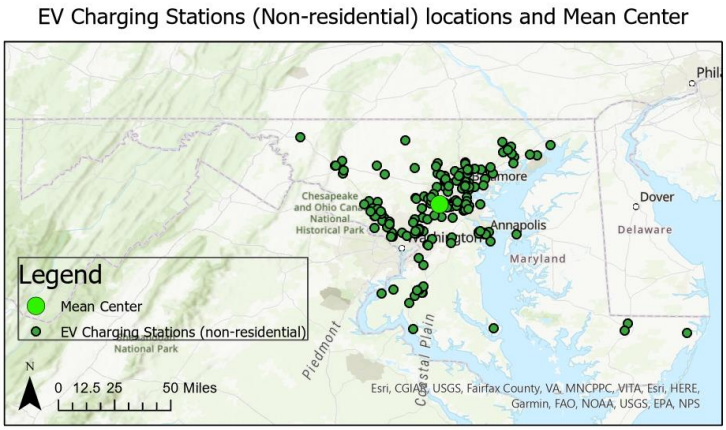
Electric Vehicle Chargers and Income

Introduction

The US vehicle market is on the brink of a massive shift toward electric vehicles (EVs) with government support to reduce the vehicle costs and increase charging stations around the country. EVs are still expensive, so this analysis looks at two variables, median income and EV charging stations, in Maryland to determine if there are any patterns and 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 by zip code: Moran's I, General G, hot spot analysis



A kernel density analysis showed that the the majority of those who took advantage of the state rebate program for installing residential EV chargers live in central Maryland, an area with more residents and commuters than other parts of the state (Figure 25).

Figure 25. EV charging stations are primarily located in central Maryland

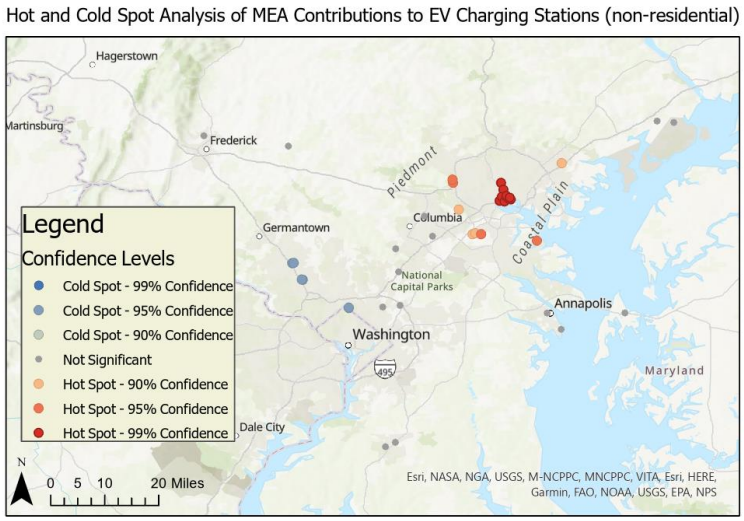


Figure 26. Hot and cold spot analysis of MEA contributions to non-residential EV charging stations

Figure 26 shows a cluster of hot spots (high government contributions) for chargers in Baltimore, and a cold spot in DC's western suburbs. Perhaps in the DC area there is strong local funding for EVs, so government funding support isn't needed, or businesses in those areas have the resources to establish their own charging stations in parking lots without government support.

Baltimore City is a cold spot for income, though there is a high number of EV chargers (Figure 27). A close look shows that many stations are located in the 'white L' of the city, neighborhoods with higher incomes and a higher white population.

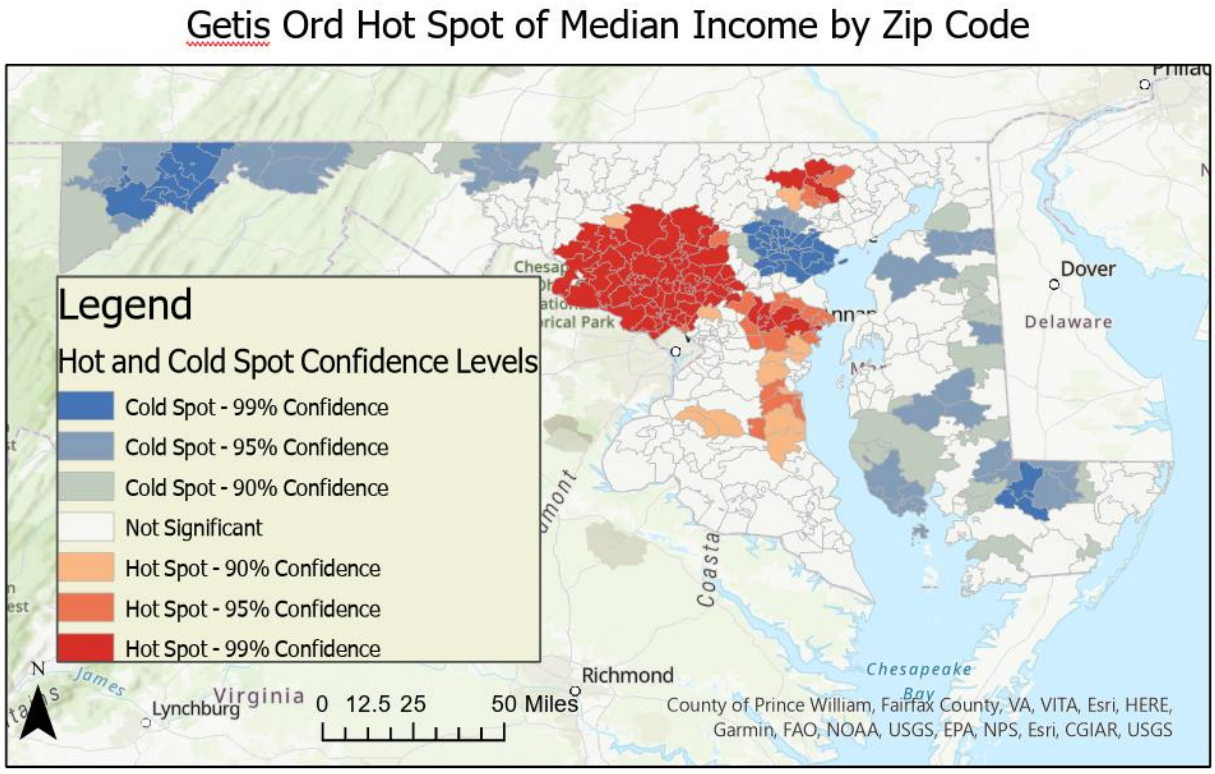


Figure 27. Getis Ord hot spot analysis of median income by zip code

Findings

Broadly, the hot spots in Maryland's wealthier regions coincide with the charging station hot spots. DC's western suburbs, primarily in Howard and Montgomery Counties, are high-income hot spots. In addition, the opposite is true; lower income areas don't have many charging stations. Maryland's western panhandle has no charging stations or residential rebates, and the Eastern Shore has very few. Income may not be the only cause, as these two regions are rural and agricultural and not as population dense. Nevertheless, income and charging stations are certainly correlated.

Conclusion

Governments have set green targets to meet the Paris Climate Agreement, and many are turning to EVs as one solution to transportation emissions. A major barrier to EV adoption, is their higher cost (Carrington). However, estimates show that EV prices will be competitive 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, 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 but should be used to supplement development of an affordable and extensive public transportation system.