FINAL REPORT

Virginia Sustainable Travel Choices: Effects of Land Use and Location on Current and Future Travel Options

Date: June 2015

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Acknowledgements
The author would like to thank MATS UTC and the Virginia Center for Transportation Innovation and Research (VCTIR) for their support of this research. In addition, I appreciatively acknowledge the insight and guidance of this project's two collaborating advisors, Peter Ohlms of VCTIR and Marcia Scott of the University of Delaware. Finally, I'm grateful for the efforts of the four graduate student researchers who assisted with this project: Chen Lu, Daniel Rauh, Yue Shan, and Mi Sun.

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Problem

Diverse states like Virginia, with a mix of urban, suburban, and rural environments and transportation systems, cannot rely on a single approach to increasing transportation sustainability, but require an understanding of what has worked and what might work for the state's wide range of communities. The Virginia Sustainable Travel Choices project examines travel sustainability across Virginia, exploring how key indicators vary by location and land use patterns. This report asks, how are Virginians increasing the sustainability of their travel today, and what travel choices, by location, may be most effective in the future?

For this report, sustainability is defined primarily as long-term environmental benefits from reduced energy consumption and greenhouse gas emissions. The analyses focuses on three potential approaches to achieving sustainability benefits through the transportation system: (1) reduced vehicle miles traveled (VMT), (2) improved vehicle efficiency, and (3) increased travel by alternative modes. This report demonstrates how VMT, vehicle efficiency, and travel mode vary across neighborhoods, counties, and the state as a whole.

Variations across the Commonwealth suggest that the most effective approaches to increasing the sustainability of the transportation system will vary depending on location and local land use. This report brings together multiple data sources on travel and land use to examine how travel in Virginia has been changing at local scales over the past five to ten years. It builds on the travel analysis within *VTrans*, the Commonwealth's long range transportation plan to provide a more detailed look at key trends impacting the sustainability of the system. The findings can inform both local and Commonwealth transportation planners as they seek to identify approaches to increasing sustainability without impacting longstanding goals of high personal mobility and accessibility.

Key objectives achieved during this project include data assembly and descriptive spatial analysis of the three indicators. This report presents findings for three key indicators of transportation sustainability, as they vary by location:

1. Commute distance by car, measured in VMT, by census tract across Virginia
2. Ultra-low and zero emission vehicles in the Commonwealth
3. Bikeshare in Northern Virginia.

Variation in each indicator over time illustrates where gains in sustainability are being made across the Commonwealth and suggests where potential benefits may (and may not) be derived in future years. The Northern Virginia component of the analysis emphasizes the potential of emerging technologies and services on transportation behavior. Services such as Uber for ridesharing and Capital Bikeshare are still very young. With such great change occurring so rapidly, this report explores the impact one service – Capital Bikeshare – is already are having in Virginia and examines its potential for expansion using density as a key indicator of potential long term success.

Transportation-Land Use Connection

Research and findings on relationships among transportation, land use, and the built environment have expanded significantly over the past two decades. Researchers have examined density, accessibility, diversity, and distribution of land uses and their effects on travel distance, frequency, and mode (Nam et al., 2011, Liu and Shen, 2011, Ewing et al., 2014). Overall, these studies show a highly complex relationship between travel and land use, with additional interactions among factors such as individual and household socioeconomic status. Liu & Shen (2011) propose a model (see Figure 1) that extends the relationship between urban form and travel to the sustainability of travel as well. They find that urban form does indirectly affect household travel decisions and energy consumption. Overall, land use characteristics such as mixed-use, increased destination density, and quality of urban form have all been shown to variously reduce vehicle miles traveled (VMT) or increase travel by alternative modes in some cases (Ewing et al., 2014). Higher employment density in particular was associated with reduced automobile usage in one particular study (Chen, Gong, & Paaswell, 2008).

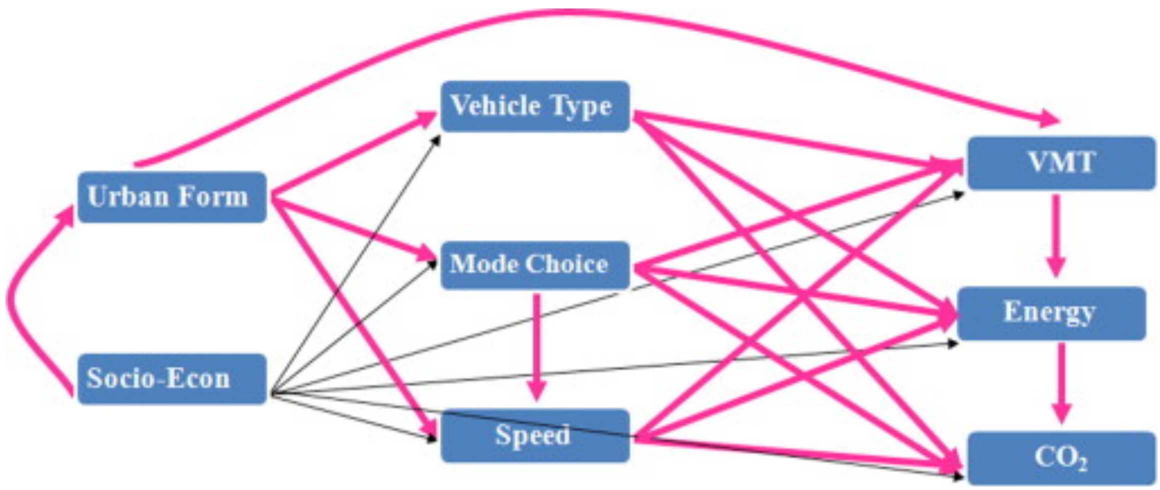

Figure 1: Interactions among Urban Form, Travel, and Sustainability (from Liu and Shen, 2011)

The reduction of VMT is perhaps one of the central sustainability goals of transportation agencies. A study published in 2011 had found that a 10% increase in residential density would equate to a 1.9% reduction in VMT's (Heres-Del-Valle & Niemeier, 2011). In another study, factors of the built environment had accounted a variation of up to 5,000 VMT annual in households (Mi & Joseph, 2014). Figure 2 from Mi & Joseph represents the travel habits of different residential locations, as modified by a variety of built environment factors.

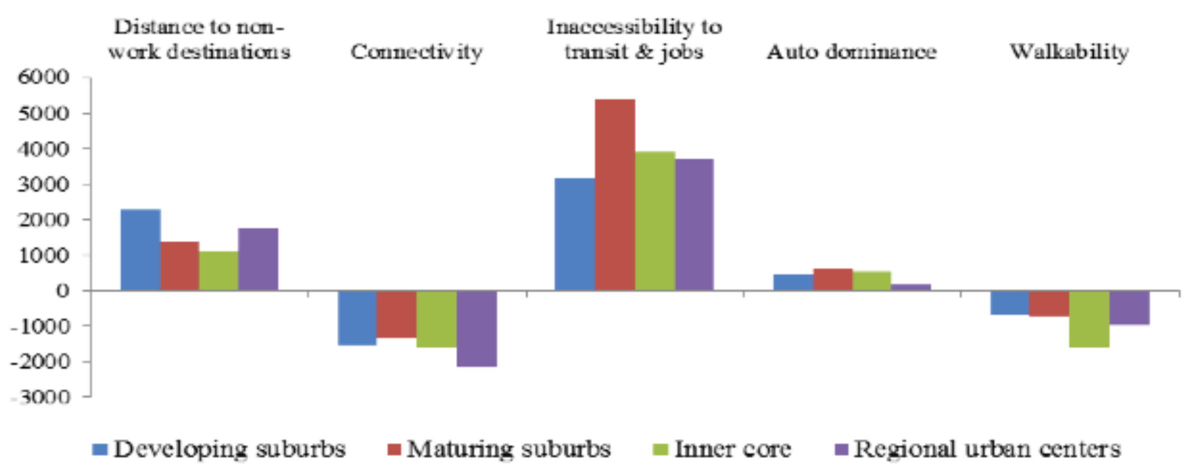

Figure 2. Relative VMT Change due to Built Environment Factors (from Mi & Joseph, 2014)

Changing Urban Form

While this report emphasizes how travel varies with land use and location, it is important to note that urban form is changing too. As described in NCHRP Report 750, population densities across the United States have gradually been increasing, both in cities and suburbs (Zmud et al., 2014). As we continue to see a steady rise in population density, transportation behaviors may change as well. Residential and employment densities have also been associated with higher use of public transit and lower automobile use (Jun et al., 2013, De Vos & Witlox, 2013). Density, alternatives to driving, walkability, and accessibility to destinations were also correlated with reduced automobile use (Shay & Khattak, 2012). A United States Public Interest Research Group 2013 report found that driving is actually on its way down in the U.S. (U.S. PIRG, 2013). A report by the same group in 2014 found that Millennials, the demographic group born between 1980 and 2000, were on average choosing to walk, bike, and take transit more relative to earlier generations (U.S. PIRG, 2014). Figure 3 illustrates the of mode split across generations measured from the 2009 National Household Travel Survey (Miller, 2015).

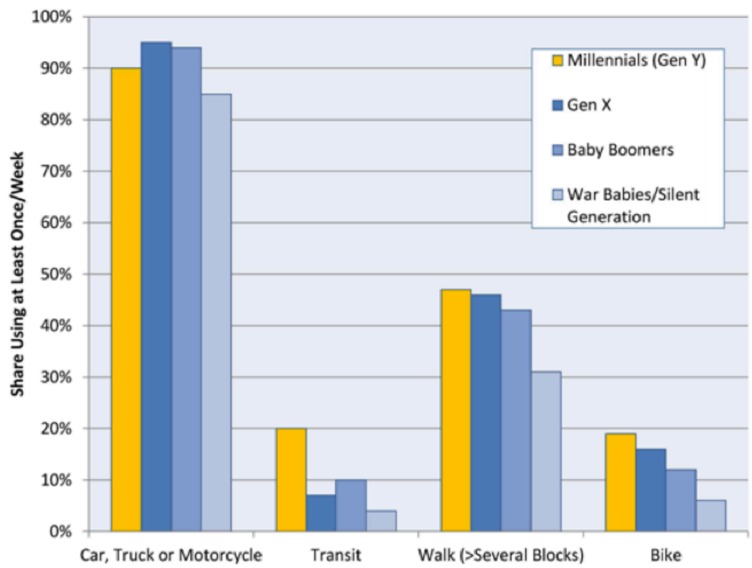

Figure 3. 2009 National Household Travel Survey Mode Splits by Generation (from Miller, 2015)

The American Public Transit Association reports that in 2014, transit ridership is at its highest point in 58 years. Amtrak ridership also rose in 2014 despite the fall of gas prices. (PRNewsire, 2014) The Acela Express and the Northeast Regional services have each set a record in ridership in 2014 as well. Intercity bus ridership is also rising in services such as MegaBus and Boltbus. The American Public Transit Association also reports an 11.95% increase in ridership in the fourth quarter of 2014 as well, a 5.36% year to date rise. (APTA, 2015). Importantly, however, while densities are increasing in cities and suburbs and shifts away from driving have occurred, many researchers caution that shifts could be temporary, due to factors such as the cyclical economy, and young adults may already be shifting their behavior and the economy improves and they enter a new stage of life (Taylor et al. 2013).

In the realm of planning practice, agencies are focusing more on Transit-Oriented Development (TOD). This form of development links public transportation, mixed-use zoning, and increasing density. A 2014 study of Washington D.C. and Baltimore found that VMT by residents living in TOD areas were reduced by 38% and 21% for the respective cities (Nasri & Zhang, 2014). Similarly, the land use and transportation connection is present in related New Urbanist thinking. New Urbanism strives to create compact, walkable locales for citizens to enjoy. The number of books and other literature written on this subject is increasing every year. These ideas have moved fully from design and planning research to practice. The Virginia Department of Rail and Public Transportation (VA DRPT) has demonstrated a commitment to linked transit and land use. VA DRPT, through their *Multimodal System Design Guidelines* (2014) seeks to identify areas of moderate to high density for the inclusion of transit, biking, and walking infrastructure.

Emerging Mobility Technologies
Mobile applications are also affecting travel behavior and decision making, with potential impacts of sustainability. New York City introduced a website that provides patrons with real time updates on bus information. Analysis of ridership attributed this technology to a 2% increase in bus users (Brakewood, 2015). Several mobile applications that were designed for transit passengers with disabilities were among the winners of New York's "App Quest 3.0". For example, the NYC Accessible app locates ADA accessibility and even notifies users when escalators and elevators are broken down. Another app, called Transitmix allows planners to create transportation routes on the fly while adjusting demographics and economics as they please. This app could help transportation planners better understand road networks. One app used in Chicago, called Ventra, allows users to utilize their smart phone as a universal fare-payment option instead of a traditional fare ticket method.

What's the Right Balance for Sustainability?
In the past, planners have looked at a variety of factors in order to determine the sustainability outcomes of transportation and land use innovations, with an emphasis on VMT and mode share among driving, walking, biking and transit. While less examined in the research, cleaner vehicles in terms of energy consumption and emissions may also have a land use or location linkages. Previous research, for example, has shown a correlation of electric vehicle owner to more central urban areas (Donna Cehn, Wang, & Kockelman, 2015). While this may be due to the distribution of income across regions, or possibly cultural differences between urban and rural areas, the variable patterns of VMT, travel mode, and vehicle type across regions suggest that sustainable travel choices, and the most effective policies to encourage those choices, will vary from place to place across a city or region. Transportation agencies seek information on tradeoffs among potential policy choices from improving transportation sustainability. For example, a Norwegian Transportation Report (2014) evaluates among investments in mode shift and cleaner vehicles, finding that cleaner vehicles may ultimately provide more sustainable outcomes for that nation. This report seeks to facilitate comparison across travel metrics that often are not included together in transportation-land use studies, particularly VMT and vehicle type.

Approach and Methodology
The specific methods for each analysis are described in their respective sections, which follow:

- Commuting Trends
- Vehicle Registration
- Northern Virginia Bikeshare

The overall approach to these analyses is to examine the spatial distribution of travel and transportation choices across small geographic scales, using geographic information systems (GIS). The precise scale of analysis varies by report section, and includes census tracts, zip codes, and in the case of the bikeshare analysis in documented in Section 6, the area within 250m of bikeshare stations. For each analysis, we endeavored to obtain data at the smallest available scale. In each of the analyses the change in the travel indicator over time provides insight into how location or land use may differentially impact the success of a given sustainability strategy.

Commuting Trends

Vehicle miles traveled (VMT) is one the most commonly measured indicators of auto-based travel behavior, and – all else being equal – higher VMT is equated with greater energy consumption and greenhouse gas production. As Figure 4 shows, in Virginia as in much of the United States, total and per capita VMT has decreased consistently since roughly 2007, at the start of the Great Recession. Note however that the decrease in VMT has leveled off in recent years, and may in fact have begun to increase again as the economic has improved post-recession. As Figure 5 shows, however, travel patterns are by no means uniform across Virginia. In this figure, the length of commutes (primarily by vehicle), may be higher outside of the large metropolitan regions in the Commonwealth, with a greater percentage of commute trips exceeding 30 miles one-way.

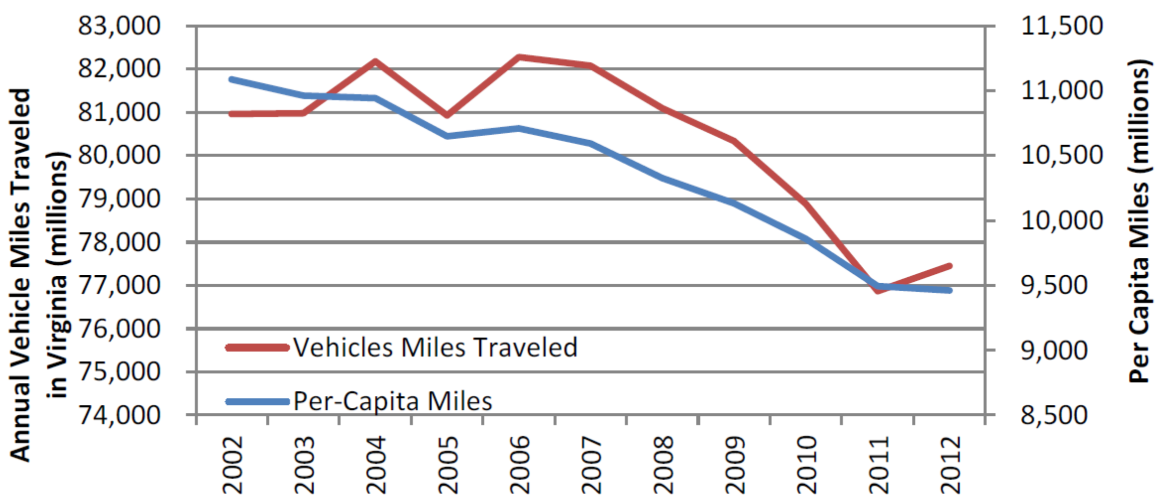

Figure 4. Aggregate Virginia VMT Trends (from VTrans 2040)

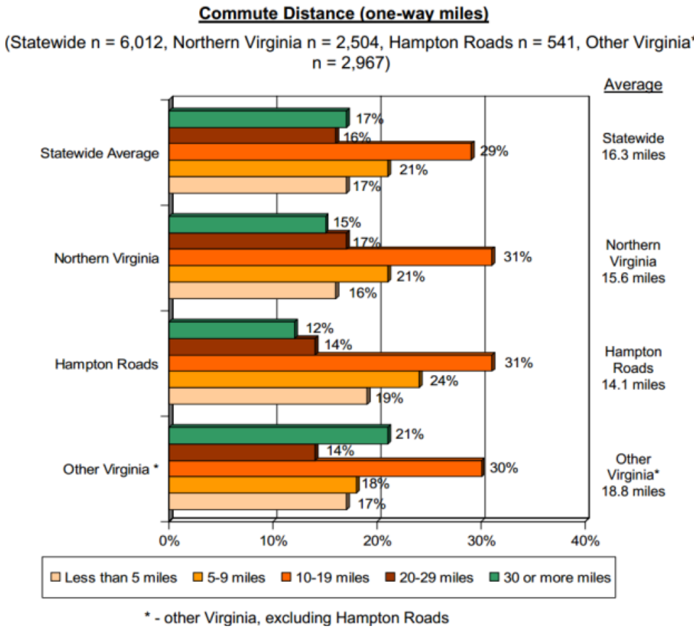

Figure 5. Commute Length by Virginia Metro (from VTrans 2040)

Average Commute Distance by Census Tract

Commute lengths vary significantly across urban, suburban, and rural parts of the state, with average commute distance by census tract changing substantially over the past ten to fifteen years. For this analysis, we utilized the Longitudinal Employer-Household Dynamics (LEHD) survey conducted annually by the US Census. The most recently available data at the census tract level is from 2011. Figures 6, 6a, 6b, and 6c illustrate average commute lengths across the state. Note that for this and subsequent figures, insets showing detail around the Northern Virginia, Richmond, and Hampton Roads metros are included as insets "a," "b," and "c," respectively.

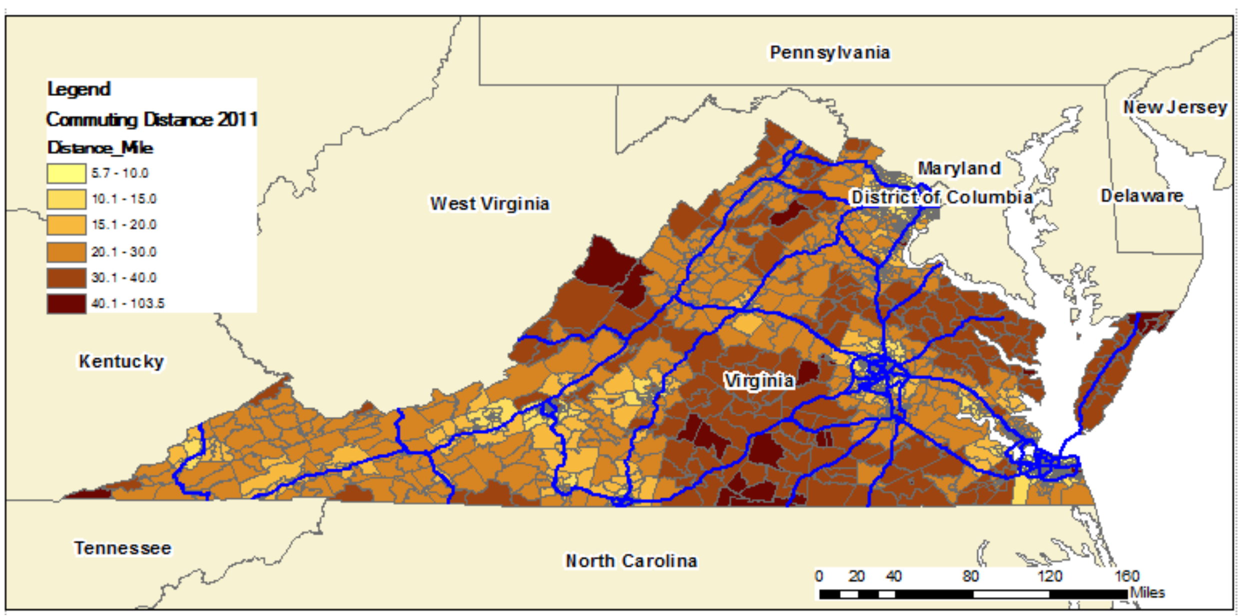

Figure 6. Average Commute Distance by Census Tract in 2011, Statewide

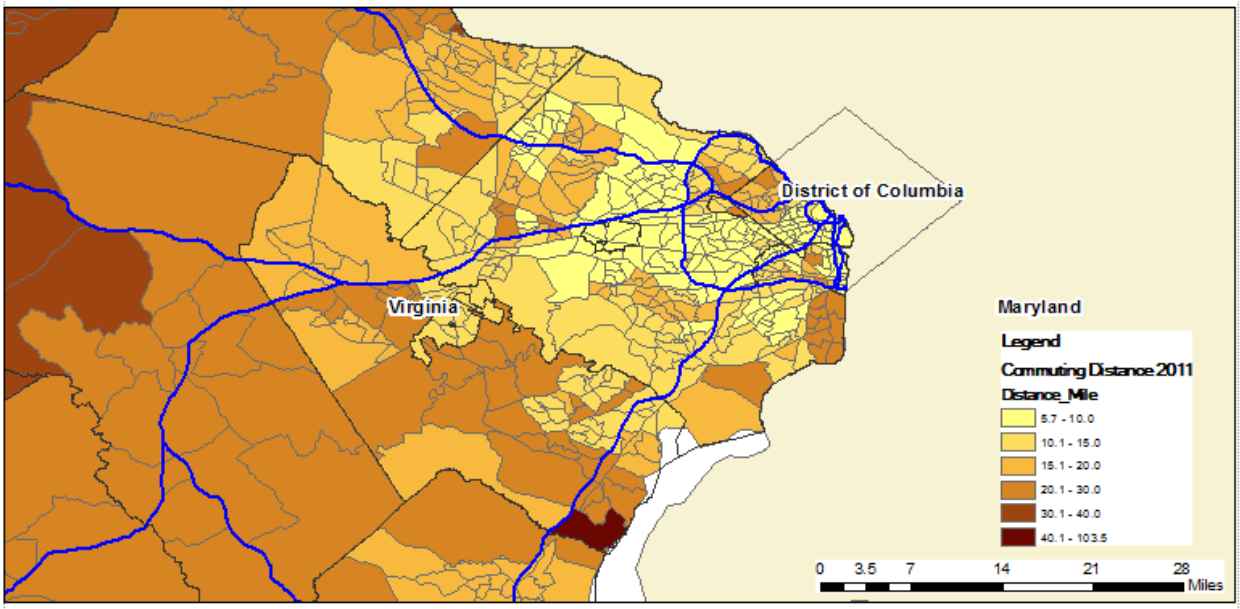

Figure 6a. Average Commute Distance by Census Tract in 2011, Northern Virginia

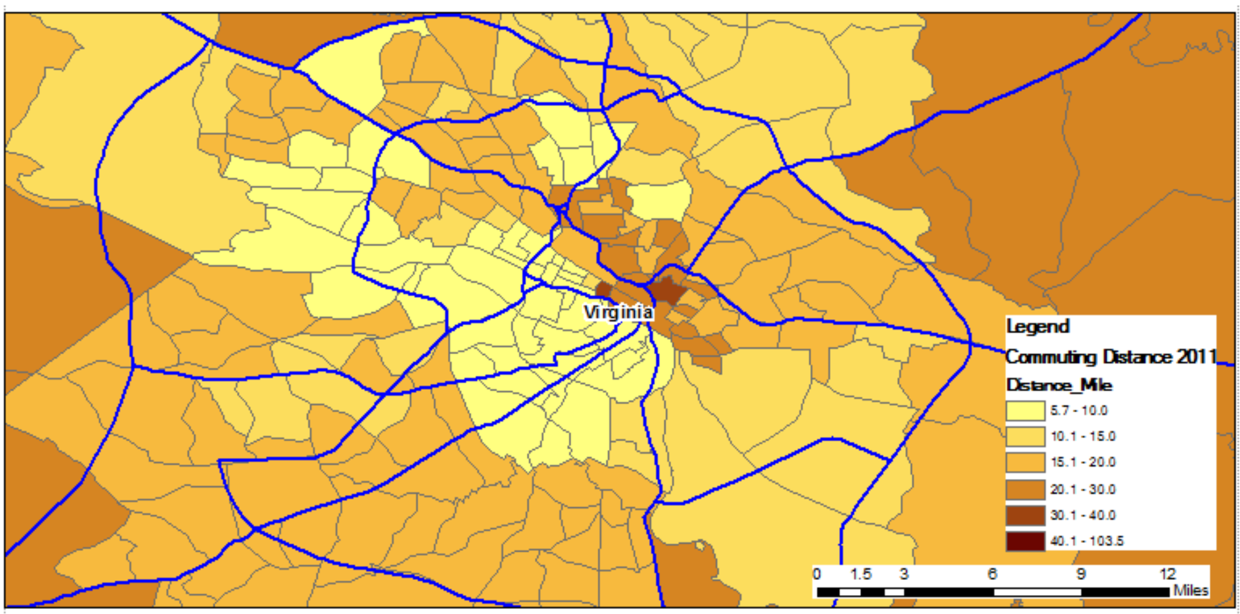

Figure 6b. Average Commute Distance by Census Tract in 2011, Richmond Metro

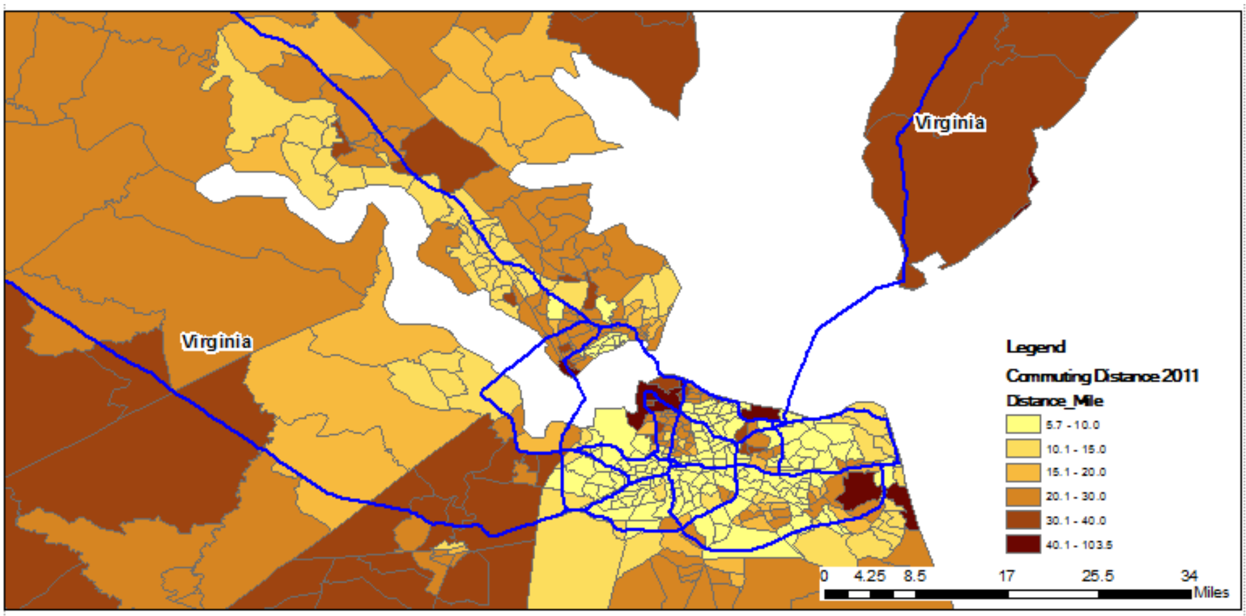

Figure 6c. Average Commute Distance by Census Tract in 2011, Hampton Roads

The data show that metropolitan areas generally have significantly shorter commutes than outlying areas. However, commutes in many suburban areas of the metros are no longer than commutes in the central parts of these metros. For example, commutes around Tysons Corner just west of the Capital Beltway in Northern Virginia are no longer, and in fact shorter, than parts of Arlington and Fairfax lying closer in to Washington DC. Commutes are also substantially shorter in the western part of Richmond compared to the eastern area of the region.

Change in Commute Distance, 2002 to 2011

How does the current state of the commute compare to patterns across Virginia earlier in the 21st century? We examined how commute patterns have changed comparing commute lengths from the earliest available LEHD data from 2002 to the latest 2011 data. Over that roughly decade long period, Virginia has seen significant changes in commute lengths by location. Figures 7, 7a, 7b, and 7c, illustrate the trends.

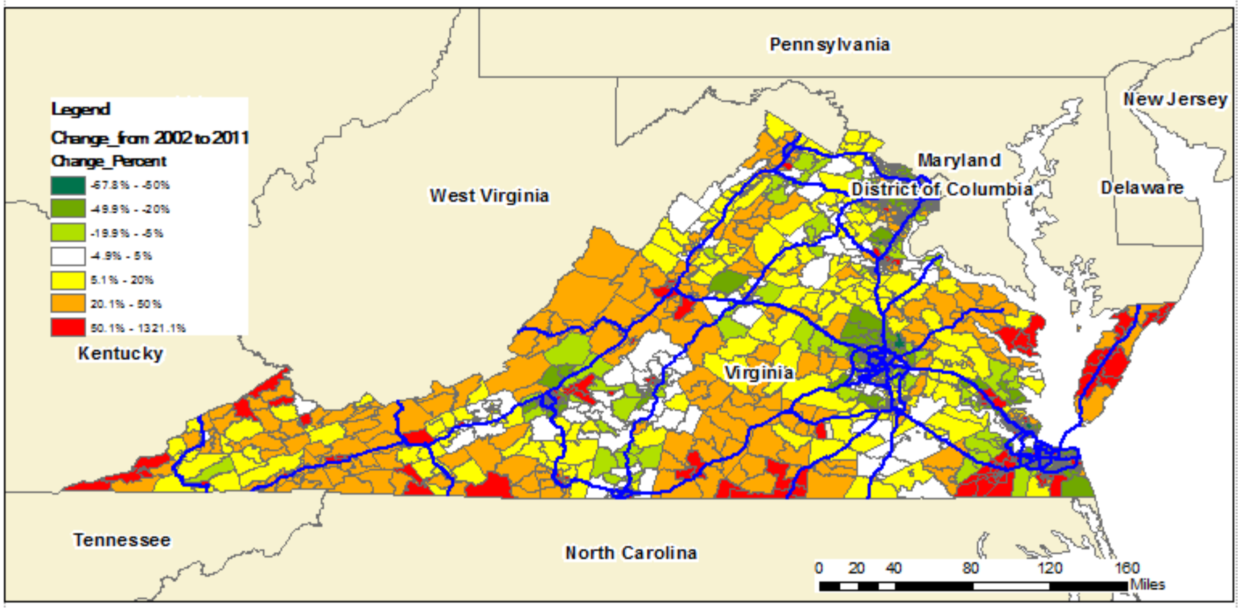

Figure 7. Change in Average Commute Length by Census Tract from 2002 to 2011, Statewide

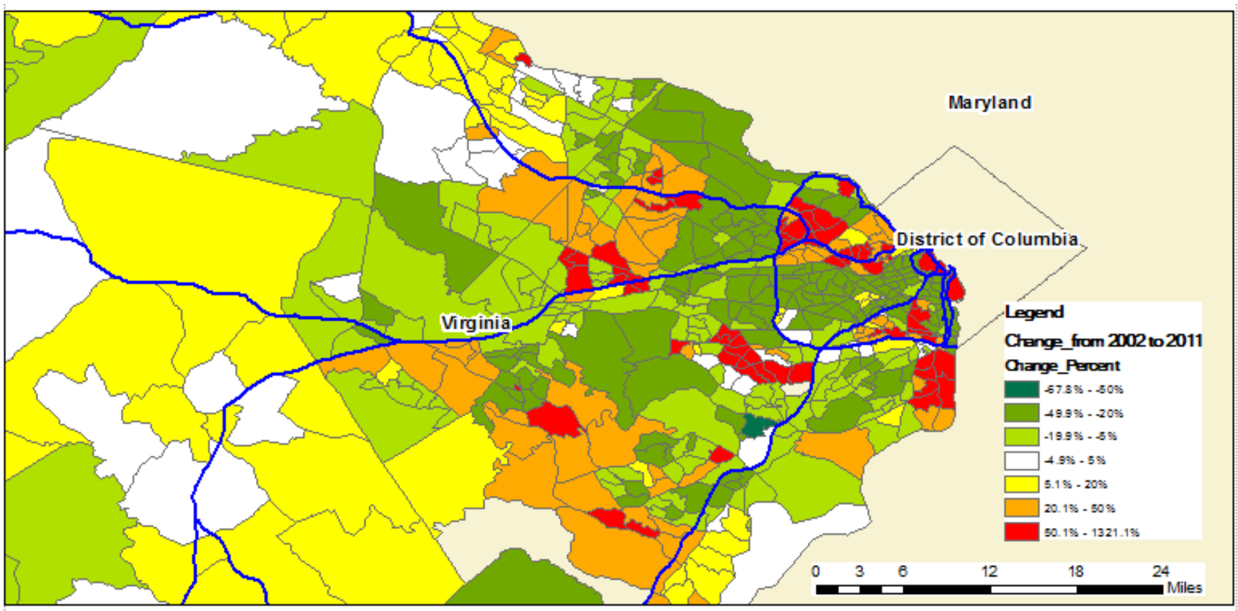

Figure 7a. Change in Average Commute Length by Census Tract from 2002 to 2011, Northern Virginia

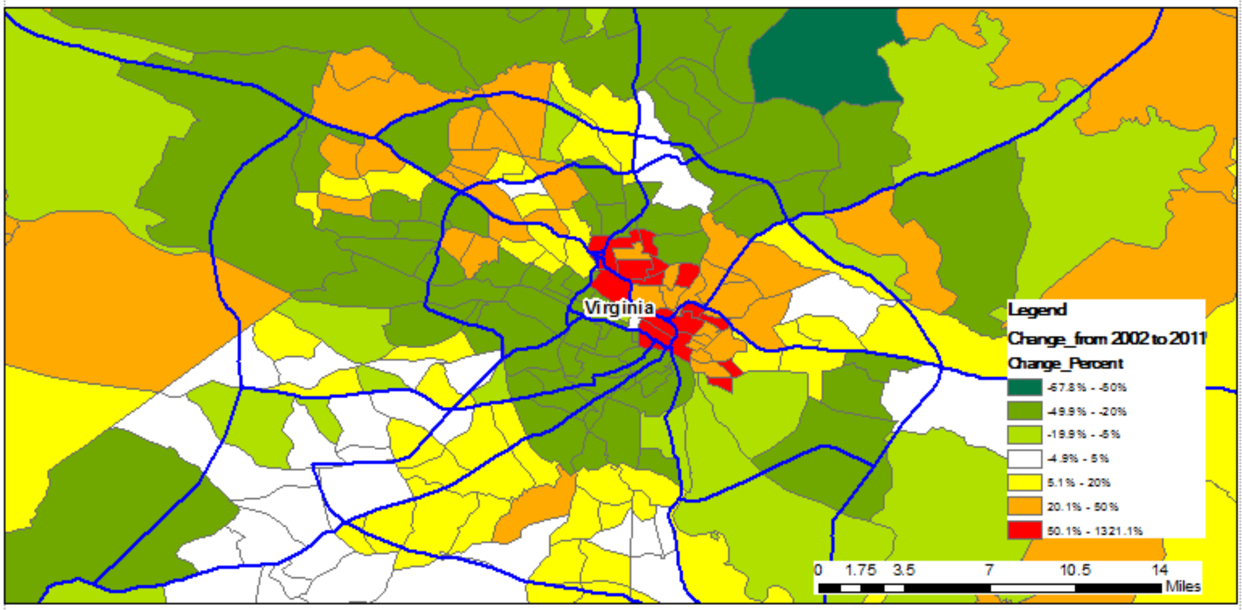

Figure 7b. Change in Average Commute Length by Census Tract from 2002 to 2011, Richmond Metro

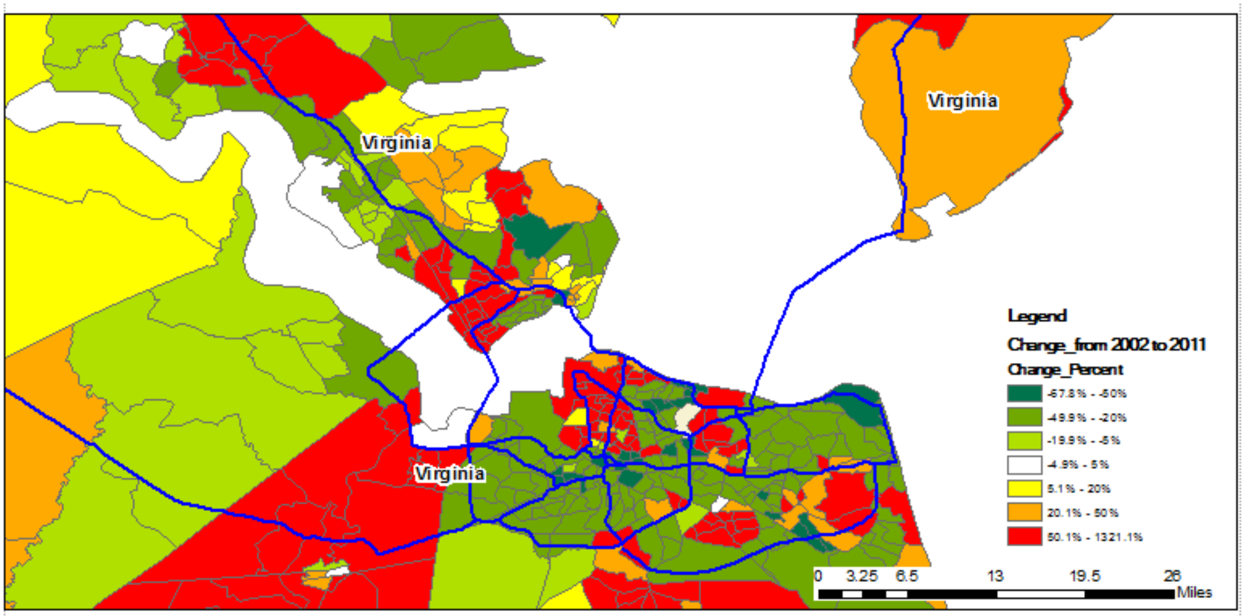

Figure 7c. Change in Average Commute Length by Census Tract from 2002 to 2011, Hampton Roads

The figures show the significant clustering among locations with increases and decreases in commute length. Overall, the reduction in miles traveled on commutes appears to be significantly concentrated within suburban areas. Conversely, many rural and central urban areas in Virginia show increased in commute lengths. Commute lengths are increasingly particularly in some of the lowest income sections of rural Virginia, in the far southwest Appalachians, in south central Virginia, and on the Eastern Shore. Commute lengths have also increased in parts of Arlington, central and eastern Richmond, Norfolk and Newport News. These urban increases are particularly stark considering the decreases in commute lengths in nearby suburbs.

With such significant changes in commute lengths across and within Virginia metros, the reasons for the changes are imperative to understand. These changes in commute distance may be associated with changes in employment location, the demographics of central, suburban, and rural locations, or other unidentified factors. Certainly, the increase in commute length in rural zones may be associated with the loss of employment opportunities in small towns across these areas. These questions are important, and the role of changing employment distributions across the state, will be examined in later phases of this research.

Vehicle Registration

As the longest trip regularly taken by most individuals, commute distance by car is an important indicator of individual and local area travel sustainability. However, while VMT is often discussed as a universal "bad," the emissions from a mile of vehicle travel varies significantly by vehicle type. Data from the Virginia Department of Motor Vehicles (VA DMV) can shed light on how relatively clean the emissions are from the driving in a particular part of the state. While the DMV releases data on the year, makes and models of vehicles registered in the state at the county level, it does not develop its own database of registrations by vehicle type at more local scales. We acquired data at the zip code level between 2006 and 2014, however, from a firm that processes vehicle registration data to this level.

Vehicle Registration Per Capita

The primary analysis in this section examines the distribution of ultra-low and zero emission vehicles – specifically hybrids and electric cars – across Virginia at the local level. Before looking at vehicle registration, however, Figures 8, 8a, 8b, and 8c illustrate per capita vehicle registrations across the Commonwealth. The data show that in terms of vehicles per person, registrations follow at not wholly surprising pattern. Registrations are lowest within the urban centers, correlated potentially with both lower incomes and higher transit and non-motorized travel opportunities. Note that, pending confirmation, the relatively higher number of vehicles per capita at the center of the Richmond Metro (Figure 8b) is likely associated with vehicles registered to the state within a zip code with relatively few residents. Additional approaches to examining vehicle registrations during future analysis, such as the distribution of registrations per total population *plus* employment in a zip code area, may reveal different patterns that link registrations more closely with local economic activity and destination accessibility.

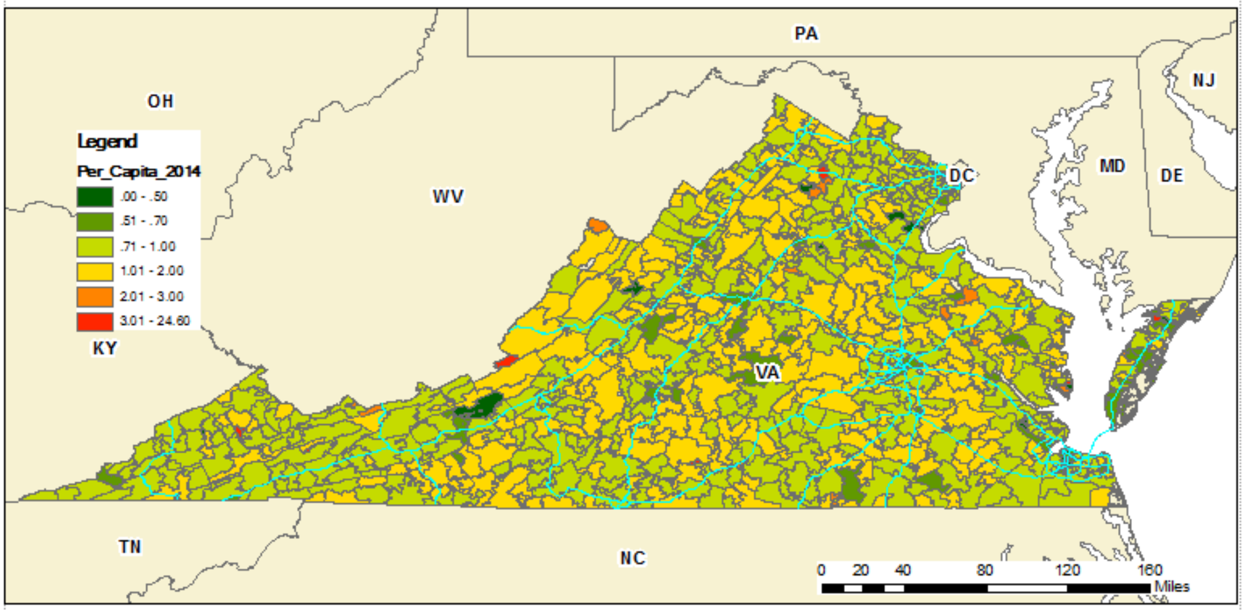

Figure 8: Per Capita Vehicle Registrations by Zip Code in 2014, Statewide

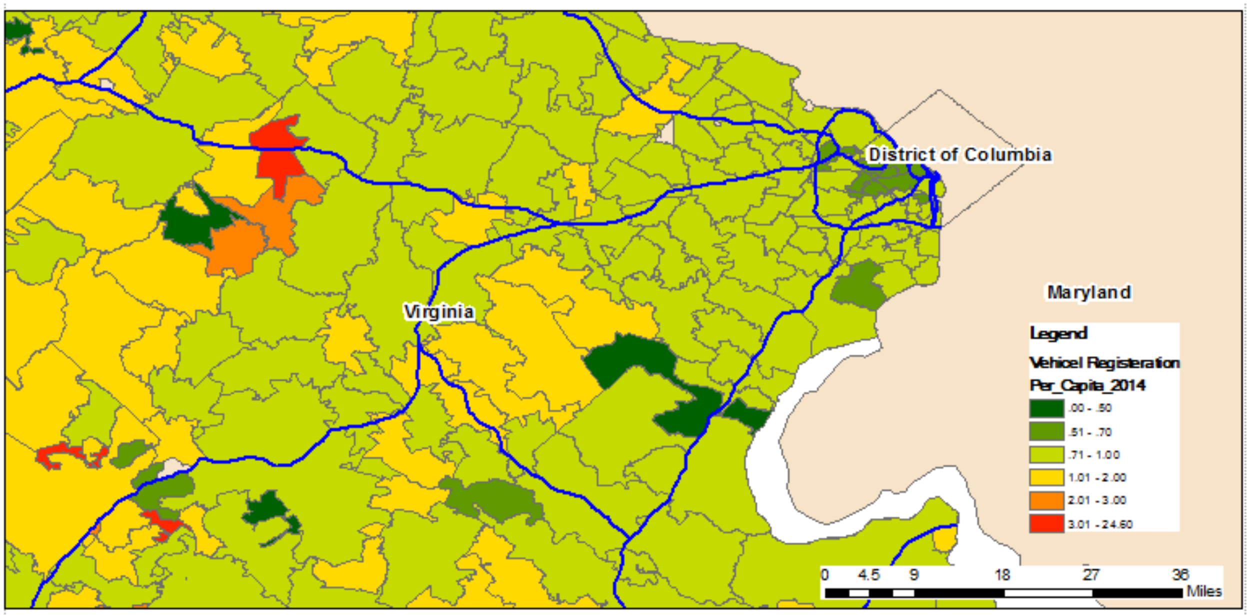

Figure 8a: Per Capita Vehicle Registrations by Zip Code in 2014, Northern Virginia

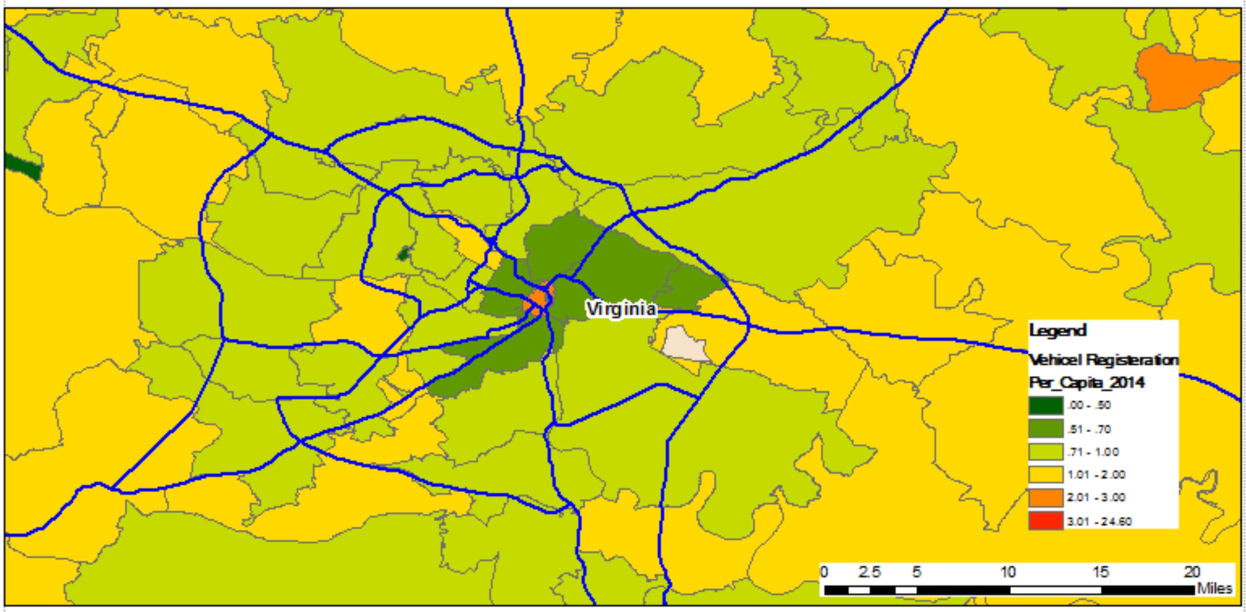

Figure 8b: Per Capita Vehicle Registrations by Zip Code in 2014, Richmond Metro

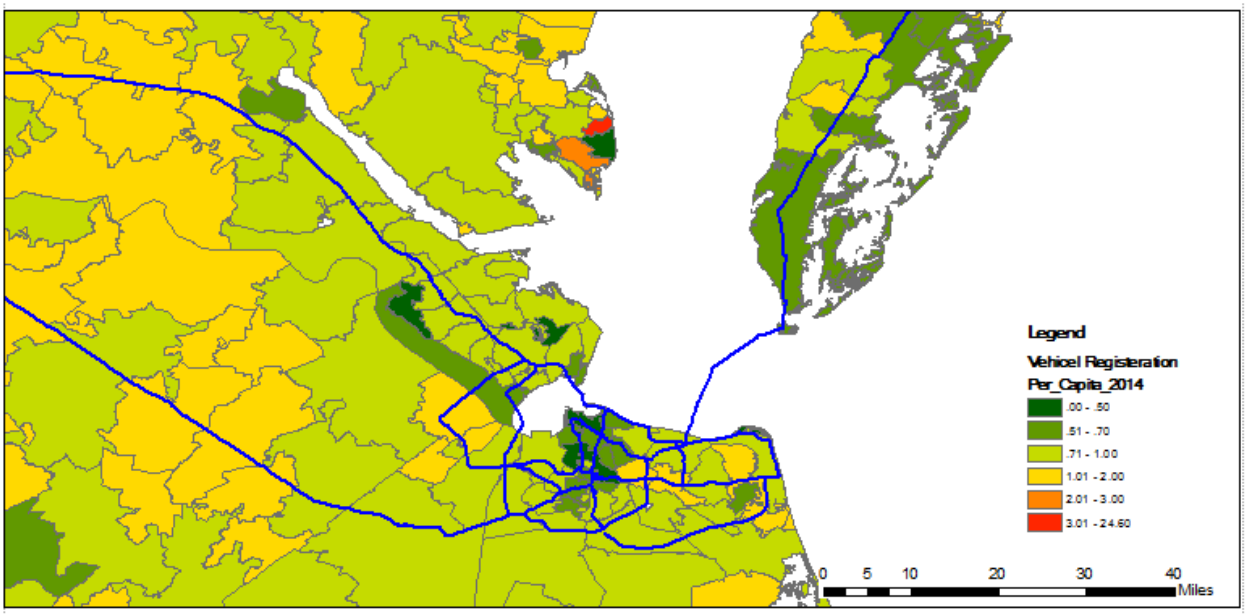

Figure 8c: Per Capita Vehicle Registrations by Zip Code in 2014, Hampton Roads

The Diffusion of "Green Vehicles" from 2006 to 2014

Over the past decade vehicles propelled by alternatives to the traditional internal combustion engine have progressed from a curiosity to a significant proportion of all vehicles in some parts of Virginia. For this analysis, "green vehicles" are defined as hybrid and battery electric vehicles. Note that hybrid vehicles still utilize internal combustion engines, but in combination with electric batteries and motors to achieve relatively higher mileage per gallon of fuel and reduced emissions. While a relatively broad category in terms of technologies, makes, and models of vehicles, hybrid and electric cars represent the cleanest category of vehicles on the road toad in terms of per mile emissions. Figures 9 and 9a illustrate the distribution of hybrid and electric vehicle registrations in 2006 throughout the Commonwealth.

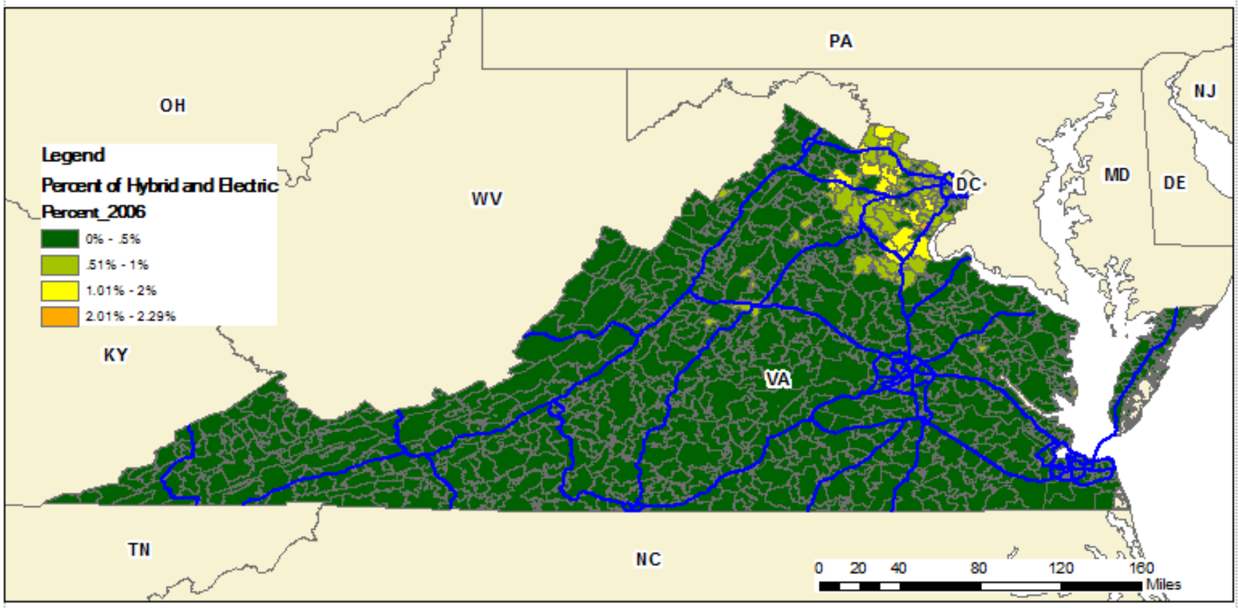

Figure 9: Hybrid and Electric Vehicles as Percent of All Registrations, 2006, Statewide

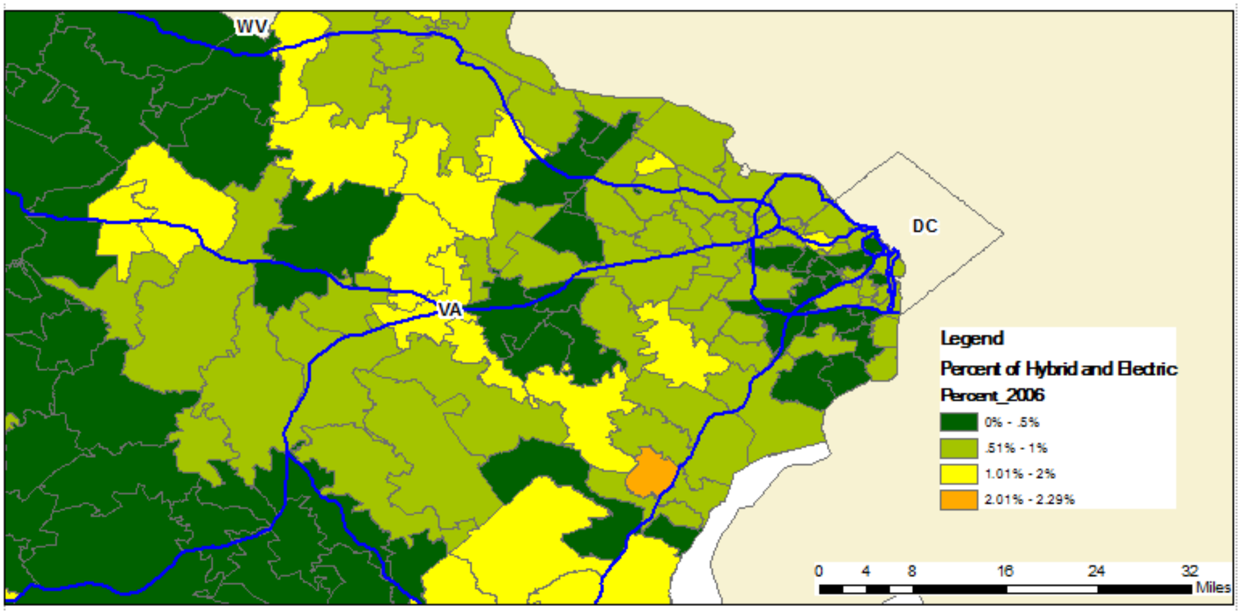

Figure 9a: Hybrid and Electric Vehicles as Percent of All Registrations, 2006, Northern Virginia

The figures show that in 2006, hybrid and electric vehicles remained a relative rarity throughout the Commonwealth. For context, the Toyota Prius was introduced to the United States in 2000, and in 2006 no mainstream electric vehicles were yet available. Throughout Virginia, the only region showing more than one half percent hybrid vehicle registration was Northern Virginia. Intriguingly, the areas with the relatively highest number of hybrid registrations at the time were primary on the fringes of the metro, in areas such as Gainesville and north to Loudon County, as well as south in Stafford County, possibly affording lower costs to households with high VMT those more exurban areas.

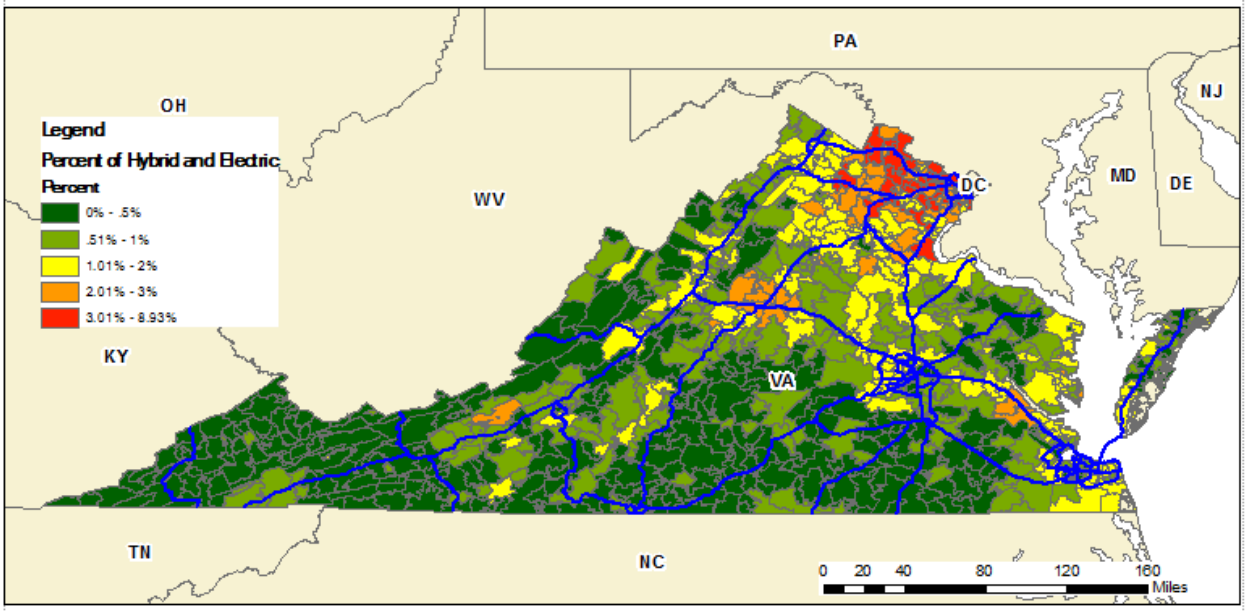

Figure 10: Hybrid and Electric Vehicles as Percent of All Registrations, 2014, Statewide

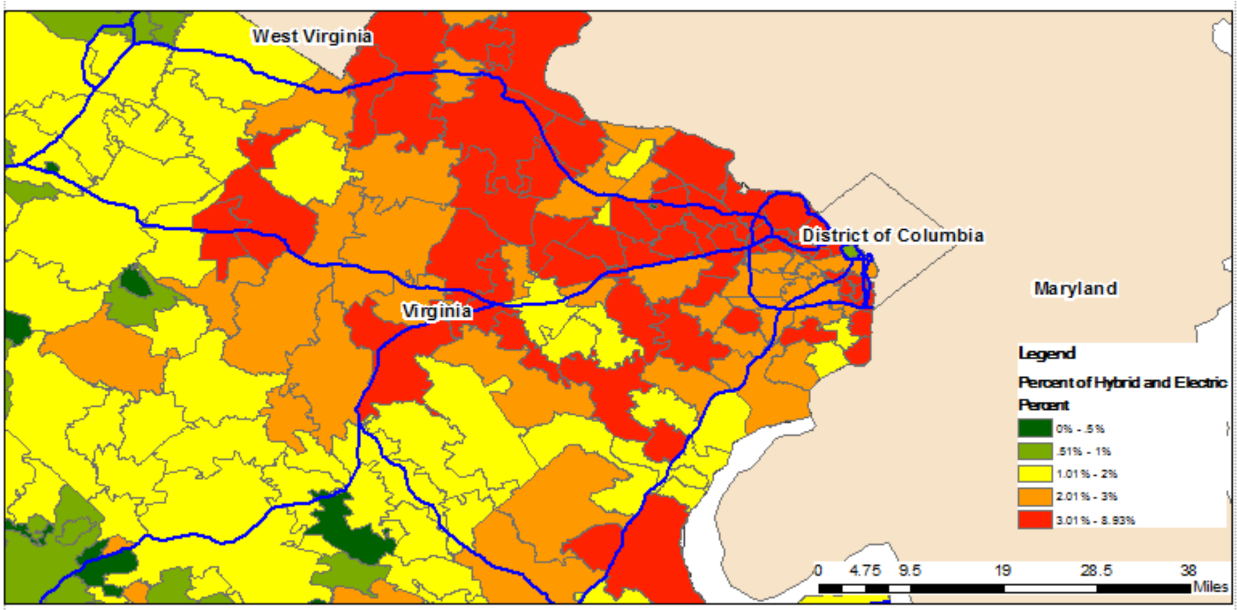

Figure 10a: Hybrid and Electric Vehicles as Percent of All Registrations, 2014, Northern Virginia

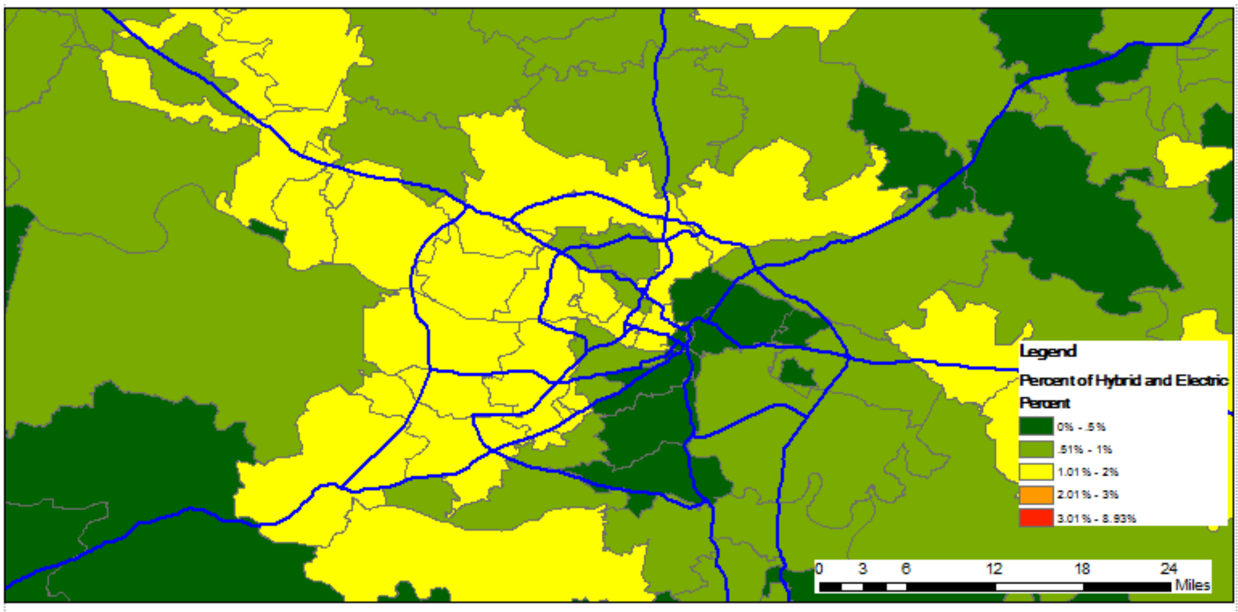

Figure 10b: Hybrid and Electric Vehicles as Percent of All Registrations, 2014, Richmond Metro

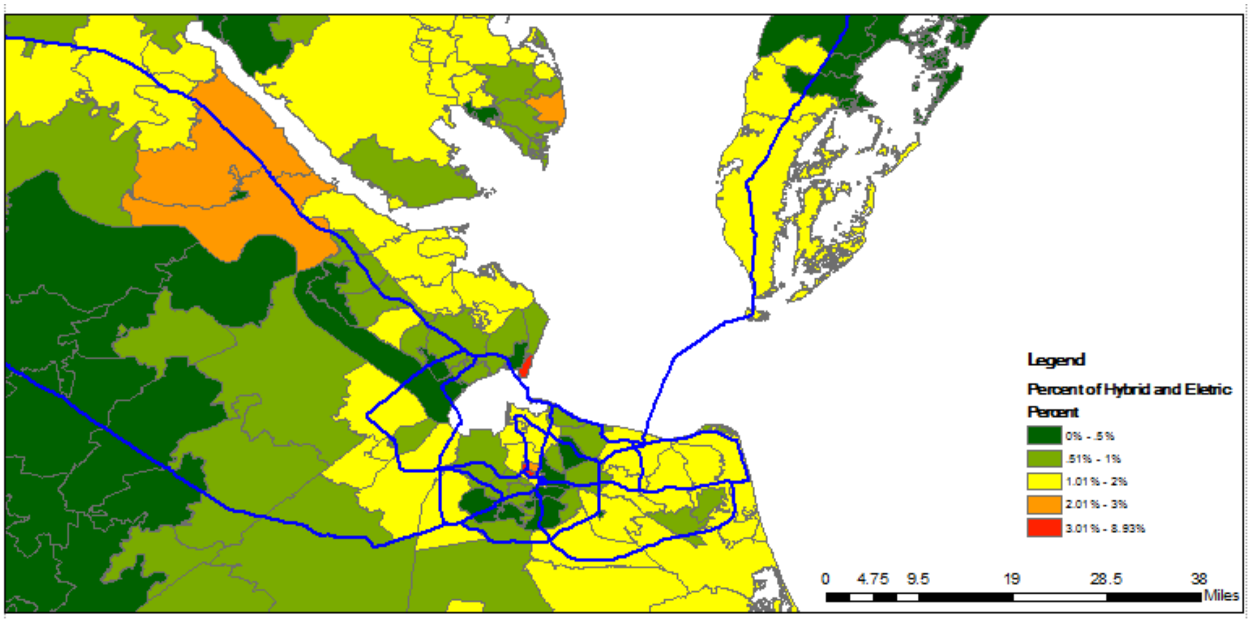

Figure 10c: Hybrid and Electric Vehicles as Percent of All Registrations, 2014, Hampton Roads

Figures 10, 10a, 10b, and 10c illustrate the explosion of hybrid and electric vehicle registrations from 2006 to 2014. By 2014, registrations exceeded 3 percent in much of Northern Virginia. Registrations are also relatively high around Charlottesville, Blacksburg, and Williamsburg, sites of major universities. Within the Richmond and Hampton Roads metropolitan areas, registrations have increased rapidly, but appear to be higher particularly specific parts of these regions – in Richmond, on the west side, and in Hampton Roads within Norfolk and then in a ring beyond the inner suburbs. These patterns are likely correlated with important socio-economic factors, including household income, as upfront costs for hybrid and electric vehicles remain higher than for other vehicles.

In rural areas of Virginia, hybrid and electric vehicles remain a rarity, despite the fact that commute distances are especially high in rural parts of the state. This situation highlights the relative disconnect between to these two key pathways to sustainability in our transportation system. As green vehicles have become more common in the state, they have diffused most rapidly through the denser, and higher-income metros. However, the largest benefits, both to individuals in terms of ongoing fuel costs and to sustainability in terms of reduced emissions, would come from the deployment of cleaner vehicles where the most daily driving occurs, in rural and fringe exurban areas.

Virginia today possesses several sustainability "sweet spots," where VMT is declining per capita and the vehicle fleet is becoming significantly cleaner. Locations of these sweet spots include places like Fairfax and Loudon County in Northern Virginia, as well as portions of suburban areas throughout the large and mid-size metropolitan areas in the Commonwealth. Ideally, all households, regardless of location would have short commutes and access to clean vehicles. However, the reality is that long-distance automobility will remain a necessity for many state residents, but because of income and potentially also marketing and household preferences, these are the areas with the lowest numbers of hybrid and electric vehicles. As the clean vehicle affordability changes, will they diffuse in significant numbers to the places where they are most needed? The trends suggest that policies encouraging clean vehicles outside of large metros remain necessary, whether through price or non-monetary means.

Northern Virginia Bikeshare

Sections 4 and 5 explored the balance among travel behavior and vehicle sustainability throughout Virginia. In much of the state, auto-based mobility remains the overwhelming mode of access to key destinations such as jobs, shopping, services, and recreation. However, some parts of the state possess robust and growing transit, bike, and walking infrastructure, particularly Arlington County and the City of Alexandria across the Potomac River from Washington DC. In 2012, more than 25% of trips to work were by transit in Arlington County, substantially more than for any other city or town in Virginia. In a place like this, trends in alternative modes are also central to understanding long term transportation sustainability. In this analysis, we ask a question that explores the fundamental linkage between land use, particularly density, and transit: How does density constrain the expansion of new forms of alternative mobility, in this case bikesharing?

Bikesharing is one of the most visible of the new information technology-driven shared modes becoming increasingly common in urban mobility, along with ridesharing and carsharing. In terms of enhancing sustainability, the availability of bikesharing is hypothesized to reduce the need for vehicular trips, whether by car or transit, giving users a choice to bike when they want, even if they don't own a bike or it is not accessible. While bikesharing may substitute for transit trips in some cases, it can also be a complement, extending the distance accessible around transit stations beyond what walking alone may provide. In the DC area, including Arlington and Alexandria, Capital Bikeshare provides bikeshare services. The system was inaugurated in 2011, and has grown steadily since then.

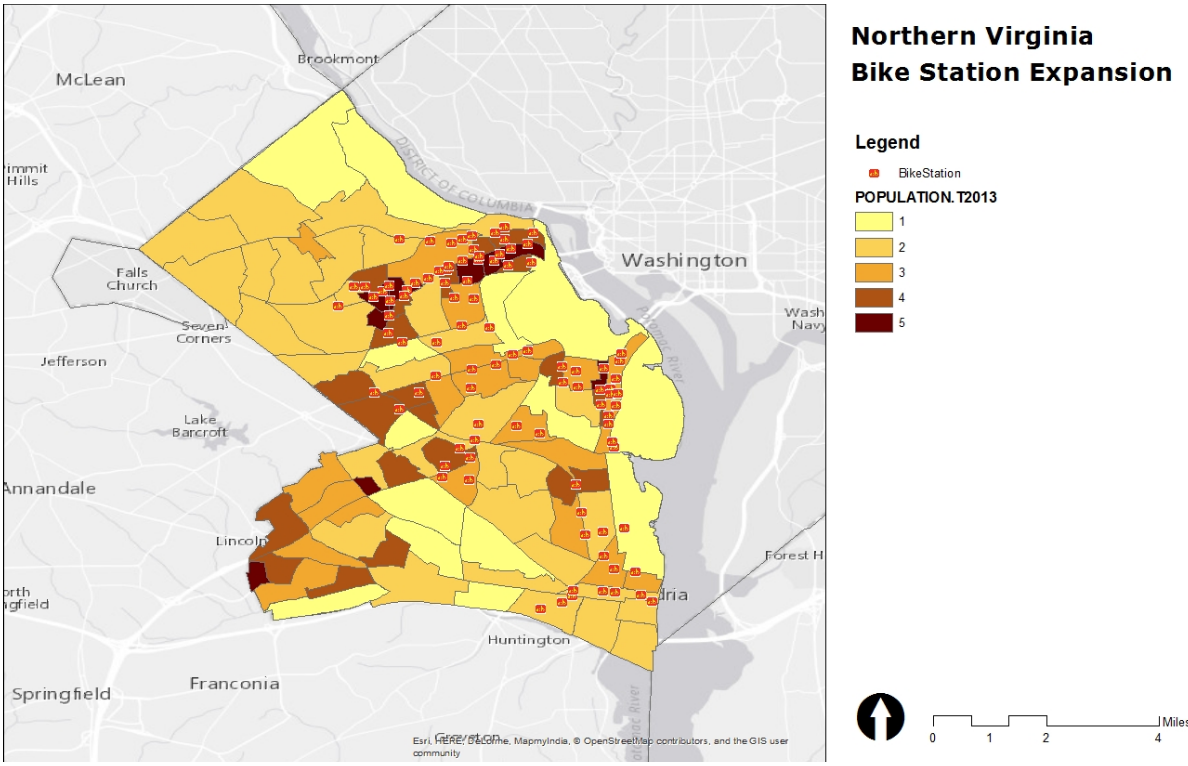

Figure 11. 2014 Distribution of Capital Bikeshare Stations, Over Population Density (2013) Quintiles

Figure 11 shows the distribution of Capital Bikeshare stations as they were distributed throughout Arlington and Alexandria at the end of 2014. Bikeshare stations are relatively clustered, particularly along the Rosslyn-Ballston corridor in the north, around Crystal City near the Potomac, and in downtown Alexandria in the south. These clusters are well aligned with areas of relatively high population density, by census tract in 2013. As Figure 12 shows, growth in stations has been relative rapid, from 11 stations at the start of 2011 to 94 stations by the end of 2014. In terms of relationship to population density, the distribution of stations has seemingly leveled off in the highest density areas since 2012, but has continued to increase in mid-density (categories 2 and 3) through 2014. Notably, stations in the lowest density parts of Alexandria have only recently begun to be installed in significant numbers. Overall, Figure 11 suggests that many of the densest parts of Arlington and Alexandria, at least in terms of population have already been relatively well covered by bikeshare stations.

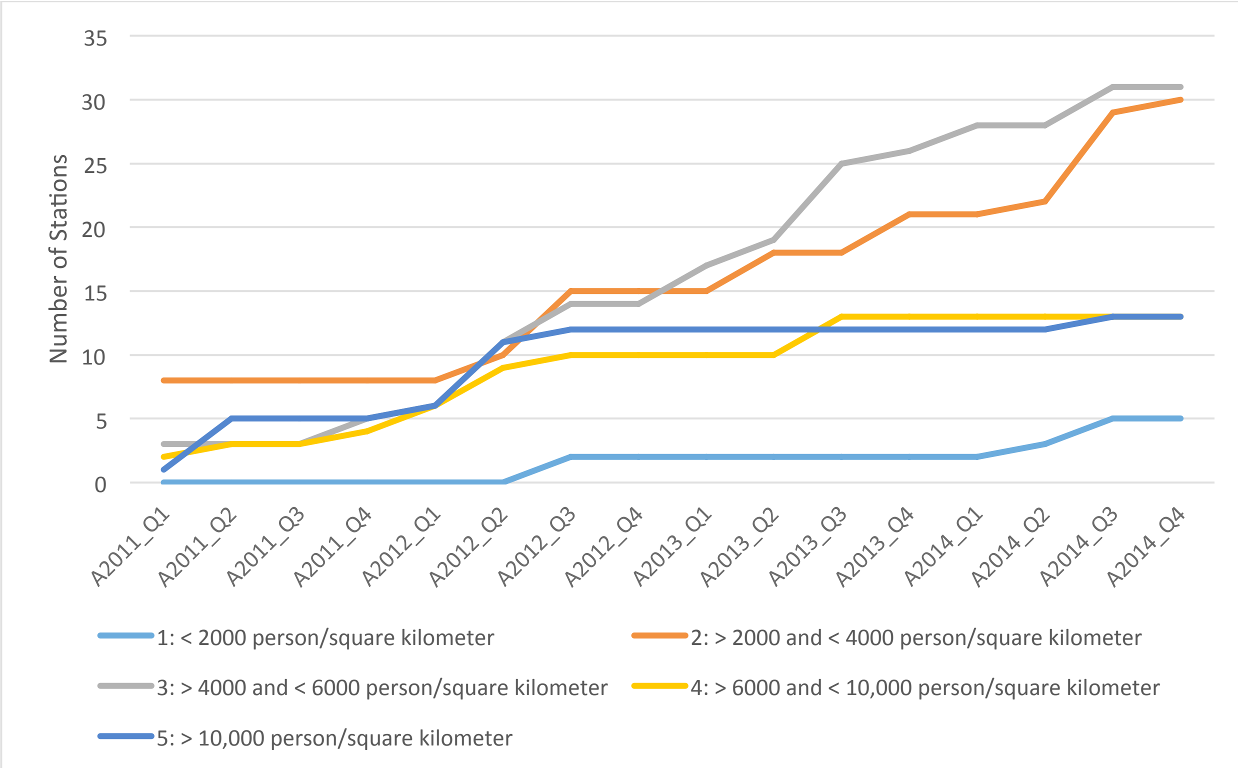

Figure 12. Growth in Capital Bikeshare Stations, 2011 to 2014, by Population Density Quintile

What, if any, has the impact of population density been on ridership levels at stations? Table 1 shows how average quarterly ridership varies among bikeshare station categorized by density. The values are "averages of averages," in the sense that ridership numbers are averaged across quarters for each station, and then averaged for all stations within a density category. Ridership numbers come from the data provided each quarter by Capital Bikeshare for all of stations in their system. At least among Categories 2 through 5, a roughly positive relationship between population density and ridership is evident. Ridership is also high for stations in the lowest density category. However, this may be anomalous, and warrents further investigation. As Figure 12 shows, only a few stations exist in this category, and those that do have only been open a short time. As more quarterly data becomes available for these stations, it is possible that average ridership will decline.

Table 1. Average Bikeshare Ridership per Quarter, by Population Density Quintile

Population Density Quintile	*Average Quarterly Ridership*
1: < 2000 person/square kilometer	625
2: > 2000 and < 4000 person/square kilometer	494
3: > 4000 and < 6000 person/square kilometer	389
4: > 6000 and < 10,000 person/square kilometer	645
5: > 10,000 person/square kilometer	782

Despite the incongruous finding for the lowest density category, the analysis suggests that bikeshare stations established at locations of lower population density are likely to generate reduced ridership. Still, several important caveats with these findings suggest immediate next steps for this analysis. Most importantly, population density is likely a second-best measure of the type of density that would impact bikeshare ridership. The destinations as well as origins would likely impact usage, so a measure of overall activity density, such as population plus employment per square kilometer, may more directly capture the conceptual relationship hypothesized. Other potential measures of land use, include destination density measures such as WalkScore, could also be appropriate. In addition, the proximity of bikeshare stations to other bikeshare stations, bike infrastructure and transit service are known predictors of bikeshare usage. Further analysis will account for these factors as well.

While the results are tentative, the possible relationship between density and bikeshare usage is an important one. As the data shows, Capital Bikeshare planners may have largely exhausted station locations in the densest parts of Northern Virginia. New stations are generally opening in lower density locations. Over time, land use density can increase. In a few cases, density may increase relatively quickly within an area, as has been planned for the Tysons Corner area of Fairfax County. However, in most urban areas densities change relatively slowly and are limited by zoning regulations. Thus, land use and density measures could be important indicators of the long-term potential growth of any bikeshare program. Because bikeshare tends to be subsidized by public funds like other forms of transit, understanding where ridership and revenues are likely to be highest, and where expansion may cause a strain on finances is an important part of operating this emerging form of transportation.

Findings: Documentation of Data Gathered, Analyses Performed, Results Achieved

The work documented here represents the first phase in Virginia Sustainable Travel Choices project under the auspices of MATS UTC. During this project, significant progress was made in understanding some of the fundamental relationships between travel, land use, location, and sustainability, setting the stage for further work examining how the policy and investment choices available to transportation agencies may vary in effectiveness across Virginia and similar places nationwide. In additional, all of the data gathered a processed is available not just for this project but others addressing similar research questions. In pursuit of these goals, the following tasks were accomplished:

Data Gathered for Virginia

- American Community Survey (US Census) Data on Population by Census Tract from 2000 to 2013
- Longitudinal Employer-Household Dynamics (US Census) Data on Employment and Commute Distance by Census Tract from 2002 to 2011
- EPA Smart Location Database for Non-Motorized Accessibility by Blockgroup, 2010
- VDOT Link and Countywide VMT Data, 2005 to 2013
- VA DMV Vehicle Registrations by Year, Make, and Model for 2006, 2008, 2010, 2012, and 2014

Data Gathered for Northern Virginia

- Capital Bikeshare Station Locations and Ridership by Quarter, 2011 to 2014
- Land Use GIS Files for City of Alexandria and Arlington County
- Bus and Metro Station and Route Data for City of Alexandria and Arlington County
- 2013 Capital Bikeshare Riders Survey

Analyses Performed

- Spatial Trend Analysis of VMT and Commute Distance for Virginia
- Spatial Trend Analysis of Vehicle Registrations, including Hybrid and Electric Vehicles, for Virginia
- Analysis of Expansion of Capital Bikeshare System over Time, Controlling for Population Density
- Analysis of Capital Bikeshare Ridership, Controlling for Population Density

Results Achieved

- Established database of mobility trends at local scales for Virginia
- Demonstrated high degree of variability in transportation sustainability trends in Virginia, underscoring spatial unevenness of measures
- Examined relationship between density and bikeshare system expansion and usage, indicating potential long-term limits to system growth across Northern Virginia

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