

Equity in Accessibility, a Case Study of City of Sacramento

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By

Meredith Milam

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Author: Meredith Milam

Date Submitted: June 2021

Cornelius Nuworsoo, Ph.D., AICP

Senior Project Advisor

Signature

Date

Michael Boswell, Ph.D., AICP

Department Head

Signature

Date

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Abstract

This paper is a Geographic Information Systems (GIS) spatial analysis of the transportation accessibility and equity in Sacramento, California. A literature review examines discriminatory regulatory policies in the 1900s that wrote racial segregation into law. The effects of these policies have lasting effects on spatial dispersal of people and create barriers to accessibility and therefore result in inequitable transportation systems. The accessibility and equity analysis in Sacramento explores demographic data, job concentration and available modes of transportation, and commuter data. The results of the analysis suggest that there is no “one-size-fits-all” approach when it comes to measuring accessibility and equity. The analysis from Sacramento reveals that car sharing programs would increase accessibility, especially for historically disadvantaged communities due to the substantially high travel speeds of private vehicles compared to conventional transit systems. However, long-term solutions would include the following:

- Fundamentally altering the intensity of land use and realigning activities along corridors that transit serves well.
- Expanding affordable housing opportunities for POCs and low-income household in the highly accessible areas of the City.

1. Introduction

1.1 Accessibility

Accessibility is an important way to measure how effective the existing transportation system is in connecting people to destinations. The greater the distance one can travel away from or to a destination, the greater the accessibility. Someone who can travel a much smaller distance than another in the same amount of time has lower mobility than the other and, in turn, lower accessibility. Someone who can get to many jobs than another in the same amount of time has higher accessibility than the other. Good accessibility to employment, education, and community amenities such as grocery stores, healthy food, healthcare, etc. is a measure of a community's quality of life.

Accessibility and equity go hand in hand and can be a crucial tool in planning. Planners can support their communities by measuring access to improve equity in the community. Accessibility maps illustrate and can identify regions or neighborhoods with varying degrees of access. Planners can then provide required assistance to specific areas.

Accessibility cannot be measured finitely; *Transport Justice*, by Karl Martens, concludes that a "sufficient level of accessibility" can only be determined by "a process of democratic deliberation and selection" (Martens 2016, 143). So, how can accessibility

be measured and what is “sufficient accessibility”? According to *Evaluating Accessibility For Transport Planning*, by Todd Litman, “Accessibility can be defined in terms of potential (opportunities that could be reached) or in terms of activity (opportunities that are reached). Even people who don’t currently use a particular form of access may value having it available for possible future use, called *option value*” (Litman 2008, 6). Options are extremely important because different modes of transportation have a variability in the distances people can travel and the places that people can get to. “Transportation options refer to the quantity and quality of transport modes and services available in a particular situation” (Litman 2008, 10).

Walking or biking gives people the opportunity to dictate their route and where they are going, however the quality of bicycle and pedestrian facilities may hinder the connectivity of these network connections. Driving a personal vehicle gives the driver the convenience and freedom to choose their route and destination. Owning a personal vehicle has many extra costs associated with it than other modes of transportation. These external costs include maintenance fees, car payments and insurance. The total costs of owning a vehicle are astronomically higher than walking, biking, or transit passes.

Todd Litman lays out how planning decisions are affected by how transportation is evaluated. “If transportation is evaluated based on vehicle travel conditions (traffic speeds, congestion delay, roadway Level-of-Service ratings), the only way to improve transport system quality is to improve roadways. If transportation is evaluated based on

mobility (movement of people and goods), then rideshare and public transit service improvements can also be considered. If transportation is evaluated based on accessibility (people's overall ability to reach desired goods, services, and activities), additional transportation improvement options can be considered (besides roadway, rideshare and public transit), including improved walking and cycling conditions, more accessible land use patterns to reduce travel distances, and telecommunications and delivery services that substitute for physical travel" (Litman 2008, 6-7).

1.2 Equity

"Social equity advocates for the equal distribution of resources, benefits, and services among individuals or socially dis-advantaged group" (Townsend, Phillimore, & Beattie, 1988 as cited in Chen, Bouferguene, Shen, Al-Hussein 2019, 221). "The goal of equity is providing the equal distribution of resources, services, and benefits among individuals and fair and appropriate distribution of them in society" (Chen, Bouferguene, Shen, & Al-Hussein 2019 as cited in Tahmasbi, Mansourianfar, Haghshenas, Kim 2019, 1). "It is important that the [equity] objectives and indicators, taken together, capture the multiple dimensions of social equity, in terms of the various policy impacts that differentially affect various groups, such as accessibility, safety, traffic noise, and transportation expenditure and affordability" (Manaugh, Badami, El-Geneidy, 2015, 8). "Transportation costs may include direct transportation user costs as well as environmental costs that result from transportation related construction, maintenance, operations, and policy changes. These environmental costs may include the direct emissions from automobile

use, traffic congestion, noise pollution, etc.” (Bills, Walker, 2017, 62). “In terms of exposures to direct traffic pollution, populations that are white and have high income have been found to be less exposed” (Stuart et al., 2009; Tian et al., 2013; Yu and Stuart, 2013; Gurram et al 2015, as cited in Guo, Chen, Stuart, Li, Zhang, 2020, 9). “Although socially-disadvantaged groups have generally been shown to enjoy greater health benefits of transportation, locality and other factors can cause variations in this overall trend” (Guo, Chen, Stuart, Li, Zhang, 2020, 9).

“An easy way for transportation planners to tackle equity issues is to focus on areas with a high share of people who belong to low-income, low-education, and minority groups” (Gaffron, 2012; Tian et al., 2013, as cited in Guo, Chen, Stuart, Li, Zhang, 2020, 9). “To improve equity of accessibility, it is essential for policy makers to provide accessible, efficient, and affordable public transit for disadvantaged areas” (Guo, Chen, Stuart, Li, Zhang 2020, 9). “Transportation benefits range from improvements in accessibility, mobility, and economic vitality on the general scale, to reductions in travel time and travel user costs” (Bills, Walker, 2017, 62). “The equity value of time is based on an average income and is used for all travel time savings, independent of the income level of the traveler that benefits from the time saving” (Martens 2017, 30). Incorporating equity into transportation planning processes is just the beginning of addressing the racist and discriminatory past that people of color (POC) have and continue to experience.

2. Premise

2.1 Study Purpose

The purpose of this study is to assess how equitable accessibility is among various socioeconomic groups in the Sacramento Metropolitan area of California. The following paragraphs explain what prompted the choice of this topic.

I studied abroad in Prague during the fall of my junior year of college and in my time in Europe, I traveled to 21 cities and 12 countries. I observed and experienced how these cultures travel and move people and goods around. I used public transportation every day while living in Prague and I loved the quality of life I had there because of their mixture of land uses. I was amazed by how inexpensive and how easily accessible public transportation was for everyone to use both in Prague and in countries I visited. I traveled to a different city each weekend and was shocked at how easy it was to figure out how to use their transportation network. I was also surprised by the availability of public transportation modes.

In Prague, I had a three-month public transportation pass that I could use for buses, trams, and the underground metro and it cost me less than one hundred dollars. The range of options for public transportation modes made their transportation network very expansive. The public transportation network was not confined to just the main corridors

of the city, it instead, reached the entire region surrounding Prague. I was able to take public transportation to the airport about eleven miles away in about thirty to forty minutes and it was not even the furthest depth of their public transportations network. I never once wished I had a car to travel nor would a car have been a better option than public transportation. When I traveled back home to America, I experienced a hard time with culture shock due to America's car culture.

When I finally arrived at the Sacramento International Airport, my family and my best friend were waiting to reunite and take me home. I was so happy to greet them after my long and exhausting twenty-four-hour journey across the world. We grabbed my luggage and my parents said we were heading to the parking garage, where their car was parked. I had grown accustomed to life in Prague and my way of moving around. I was in autopilot expecting to walk out of the airport and get in line for the 109 bus that would drop me off at the metro station. I was so disappointed when we walked across the skywalk and into the airport's parking garage to find our vehicle. It was the weirdest, most unfamiliar feeling stepping into a car that was personally owned and driving away from the airport without having to wait outside for the bus to pick me up. On that first car ride home, all I could think about was how massive the freeway was, how spread out everything was, and how many cars were on the road.

I drove for the first time since leaving for Europe two days after arriving home to Rocklin, California, about twenty miles from the capitol, Sacramento. I was easily able to adapt to driving again, but I had a hard time accepting the fact that driving my personal

vehicle was my only option for a mode of transportation. I quickly became frustrated with my inability to get places. I found that in America, my options for transportation were extremely minimal; I could walk, drive my car, or take public transit which in Rocklin is the county bus. In Prague, the transportation modes that were available and affordable to me were the bus, tram, underground metro, train, rideshare, bikeshare or scooter-share, intercity bus, and airplane.

I decided then that I wanted to dive deep and learn more about how accessible and equitable transportation is in America, but more specifically Sacramento. This led me to become a research assistant for Fehr & Peers on an accessibility project. My role in the project was to analyze the transportation network in the Sacramento region by mode and find out how far a person can travel from a specified location in specific time increments. I produced accessibility isochrone maps to illustrate the distance an individual can travel in a specified time by walking, biking, driving, and by public transit (city/county bus, light rail). I wanted to further continue my research on this topic, so now it is my senior project. I chose to add the element of equity to accessibility and analyze the results. My project aims to look at research and gather evidence on how to successfully increase accessibility and equity in transportation in Sacramento. I used GIS to spatially analyze data and compare those results with evidence from literature.

2.2 Study Methodology

This paper provides context on the history of inaccessible and inequitable transportation in the United States and how that is applicable to inaccessibility outcomes in Sacramento, California. ArcGIS Pro was used to spatially analyze the accessibility and equity in the City of Sacramento by block groups. The U.S. Census American Community Survey (ACS) 2018 5-year estimates were the table inputs to find: the number of people who are not white by block group, percent of the population of block groups that are Hispanic or Latino, and the percent of the population below the poverty threshold (15%) in block groups. Open Street Map (OSM), National Data & Surveying Services (NDS), General Transit Feed Specification (GTFS), Fehr & Peers Network Analyst Tools and Scripts were all used to create the accessibility maps. The accessibility analysis analyzed four modes of transportation – walk, bicycle, transit, personal vehicle – by the distance each mode allowed an individual to travel, in 5-minute increments.

3. Background

We must first understand how transportation planning has excluded populations in American history, and then take a deeper look into Sacramento's excluded populations. City planning has a long history of discriminating POC, and low-income populations, so the first step is to examine how transportation planning has limited accessibility.

The 1866 Civil Rights Act declared "housing discrimination was unconstitutional, [but] it gave the government no powers to enforce it" (Rothstein, 2017, Preface). Section 1 of the Thirteenth Amendment abolished slavery, "and Section 2 empowers Congress to enforce Section 1" (Rothstein, 2017, Preface). So, housing discrimination based on race have been unconstitutional since 1866, but policymakers still wrote racial exclusions into federal, state, and local policies. In the mid twentieth century, policy enforced racial segregation. Suburbanization immensely increased segregation in America. Racial barriers blocked POC from moving to the suburbs.

3.1 Suburbanization

3.1.1 GI Bill and the New Deal

There was a major housing shortage in mid-twentieth century due to external costs of World War II. The Great Depression and World War II dampened housing supply until after the war when housing demand exploded and created a huge housing shortage.

Becky Nicolaides and Andrew Wiese state in their article, *Suburbanization in the United States after 1945* “experts estimated a shortage of 5 million homes nationwide...As late as 1947, one-third were still living doubled up with relatives, friends, and strangers” (Nicolaides, Wiese. 2017, 2). This led to federal funding “that revolutionized home building and lending, subsidized home ownership, and built critical suburban infrastructure such as the new Interstate highway system” (Hayden 2003, Hanchett 1996, Gutfreund 2005 as cited in Nicolaides, Weise, 2017, 2) that largely benefited white people.

African Americans were excluded in federal policy even after the passing of the Thirteenth Amendment and the Civil Rights Act of 1866. The Federal Housing Administration (FHA) in the New Deal stated the exclusion of African Americans explicitly in participating in growing equity in residential properties. Additionally, the G.I. Bill gave loans to white veterans moving back to America which were low-cost, low-interest, and aimed to go towards mortgages for single-family homes. Black veterans returned to war and were not offered any federal assistance. “By 1960, African Americans and other people of color had received just 2% of FHA-insured mortgages” (Jackson, 2004 as cited in Nicolaides, Weise, 2017, 6). Jackson further explains “Mechanisms of segregation included collusion by real estate brokers, homebuilders and lenders, discriminatory federal housing guidelines, local neighborhood associations, municipal land use controls, and the threat of violence” (Jackson, 2004 as cited in Nicolaides, Weise, 2017,6). The FHA approved suburb projects on a racial basis, these

projects outlined the exclusion of African Americans, and was blatantly racist and unconstitutional.

3.1.2 Redlining

“In 1933...the administration created the Homeowners’ Loan Corporation (HOLC)...The HOLC created color coded maps of every metropolitan area in the nation with the safest neighborhoods colored green and the riskiest colored red. A neighborhood earned of red color if African Americans lived in it, even if it was a solid middle-class neighborhood of single-family homes” (Rothstein 2017, 55). The red colored neighborhoods on the maps became known as “redlined neighborhoods.”

“The extraordinary growth of California and the West in the decades following World War II was financed on a racially restricted basis by the federal government” (Rothstein 2017, 65). Residential segregation fiscally impacted disparities in education, public funding, public services and more. White neighborhoods were considered more affluent, but the government provided them the resources to build their communities and equity.

3.1.3 Automobiles

American cities were dominated by the automobile and automobile companies pushed policy makers to build more roadways. “Throughout most of the 20th century, transportation planning goals were almost entirely mobility-based, with a focus on congestion reduction and time savings for motorists, and safety” (Manaugh, Badami, El-

Geneidy 2015, 1). Karl Marten explains “the dominance of the motor car resulted in a vast dispersal of urban functions over space, eliminating walking as a feasible alternative for most trips as result motorized transport change rapidly from a luxury into a necessity. Few people in industrialized societies are now able to manage their daily lives without individualized or collective motorized transport” (Martens 2017, 55). The reliance on car ownership data [in an accessibility analysis]... is problematic” (Martens 2017, 186) because of forced car ownership typical in suburban and rural areas and persons with sufficient income to afford a vehicle but chose to live without a car.

In a public transport system of poor quality, “there may be a certain degree of forced car ownership among low-income persons, especially in more suburban and rural areas (Martens 2017, 186). Car ownership is ‘forced’ on a person or household has limited capacity to afford the high costs of car ownership and use yet can hardly avoid these costs because of a lack of alternative means of transportation in combination with the spatial dispersion of out of home activities.” (Martens 2017, 186). “Also, there are disparities in public investment among different socio-demographic populations” (Kravetz and Noland, 2012 as cited in Guo, Chen, Stuart, Li, Zhang, 9).

3.1.4 Federal-Aid Highway Act

Nicolaides and Wiese further explain that residential suburbs were far away from the city center and they lacked access to work, school, markets, etc. Housing and jobs were further distances, leading to the Federal-Aid Highway Act (FAHA). Households in the suburbs required a car to travel longer distances to their destinations. Major

infrastructure needed to be built to connect the suburbs to the city center. The FAHA was “known for its role in connecting the country through the interstate highway systems...[and was] conceptualized as a unifying, positive movement in U.S. economic history. The new highway system facilitated economic growth, suburban expansion, as well as improved domestic transportation of goods resulting in the expansion of several industries including fast food, trucking, construction, and automobile production. However, this fiscal expenditure expedited the deterioration of inner cities with large African American populations. The economic despair in the African American community is a rarely acknowledged outcome of the FAHA. The FAHA, one of the largest fiscal policy decisions in the history of United States, serves as a nuanced way of looking at race based economic principles and its contemporary implications” (King, Finley 2015, 197). African American communities were purposely demolished for highway infrastructure, continuing to segregate and displace communities. Highways connected suburbs to the core urban area and jobs to cut down on commute time.

3.1.5 White Flight

“In the postwar period, black migrants settled disproportionately in central cities...If whites have some distaste for living near blacks, black migration will be associated with declining urban population and, in some cases, falling housing prices” (Boustan 2010, 421). White people emigrated from central cities into affluent, segregated suburbs.

Leah Platt Boustan explores black migrants impacts on city’s populations and housing markets and causes of suburbanization. Her study showed “that cities that received

more black migrants from 1940 to 1970 lost a greater number of white residents” (Boustan 2010, 438). “Black migration from the rural South to industrial cities in the North and West coincided with the development of post war suburbs” (Boustan 2010, 437). Her “estimates suggest that the change in racial diversity associated with black migration resulted in a 17% decline in urban population” (Boustan 2010, 438). In 1978-79, Jan Blakeslee explained that “over the past two decades [1950s-1970s], the plight of America's cities has become almost a commonplace of social comment, while city tax bases are eroding and their job markets declining as companies seek cheaper, newer, or more assessable facilities in the suburbs, their schools and services struggle against the combined impact of inflation, unemployment, and shrinking federal assistance. The cities are seen increasingly as deteriorating ghettos for the poor, the unemployed, and the disadvantaged-above all, for minorities (Blakeslee 1978-79, 1). In 1973, 64% of the metropolitan poor lived in the central cities” (US Census Bureau 2018 as cited in Blakeslee 1978-79, 1).

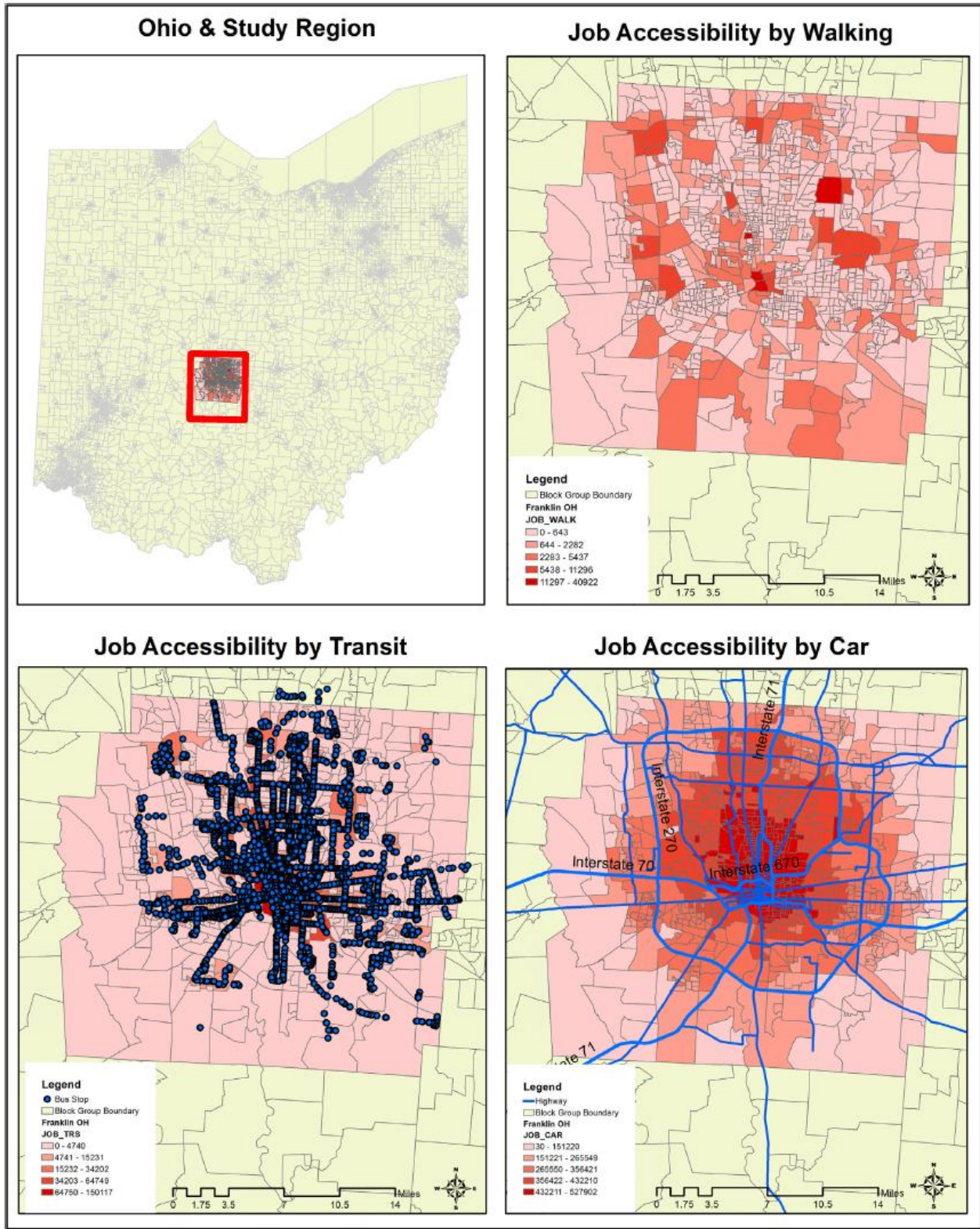
4. Case Studies

4.1 Columbus, Ohio

4.1.1 Background

The case study of Columbus, Ohio focuses on addressing equity issues by “improving job accessibility based on transport connectivity” (Wang, Chen 2015, 1). The methodology of this case study includes a “GIS-based job accessibility by walking transit and car and three transport based spatial autoregressive models [that] are used to account for the spatial autocorrelation of job accessibility among neighboring block groups while controlling for built environment and socioeconomic factors” (Wang, Chen 2015, 1). The goal of the case study was to identify spatial patterns and identify accessibility and equity deficiencies to improve job accessibility and improve equity in Columbus, Ohio.

Figure 4-1 Job Accessibility by Mode



Source: C.-H. Wang, N. Chen (2015)

4.1.2 Key takeaways

- “The results also show that walking-accessed jobs are primarily related to physical settings (e.g., land uses) at the local level” (Wang, Chen 2015).
- “Locations with a higher share of zero-vehicle housing units have better job accessibility by transit” (Wang, Chen 2015, 1).
- “Locations with a higher share of single-parent households are at a disadvantage in overall job accessibility. Due to its complex transportation needs, a society friendly to single parents should spatially integrate accessible jobs with other needed activities via land-use and transportation planning” (Wang, Chen 2015, 1).
- “Car-ownership programs and non-spatial social supports also might be effective to help secure job opportunities and perform daily life activities” (Wang, Chen 2015, 1).

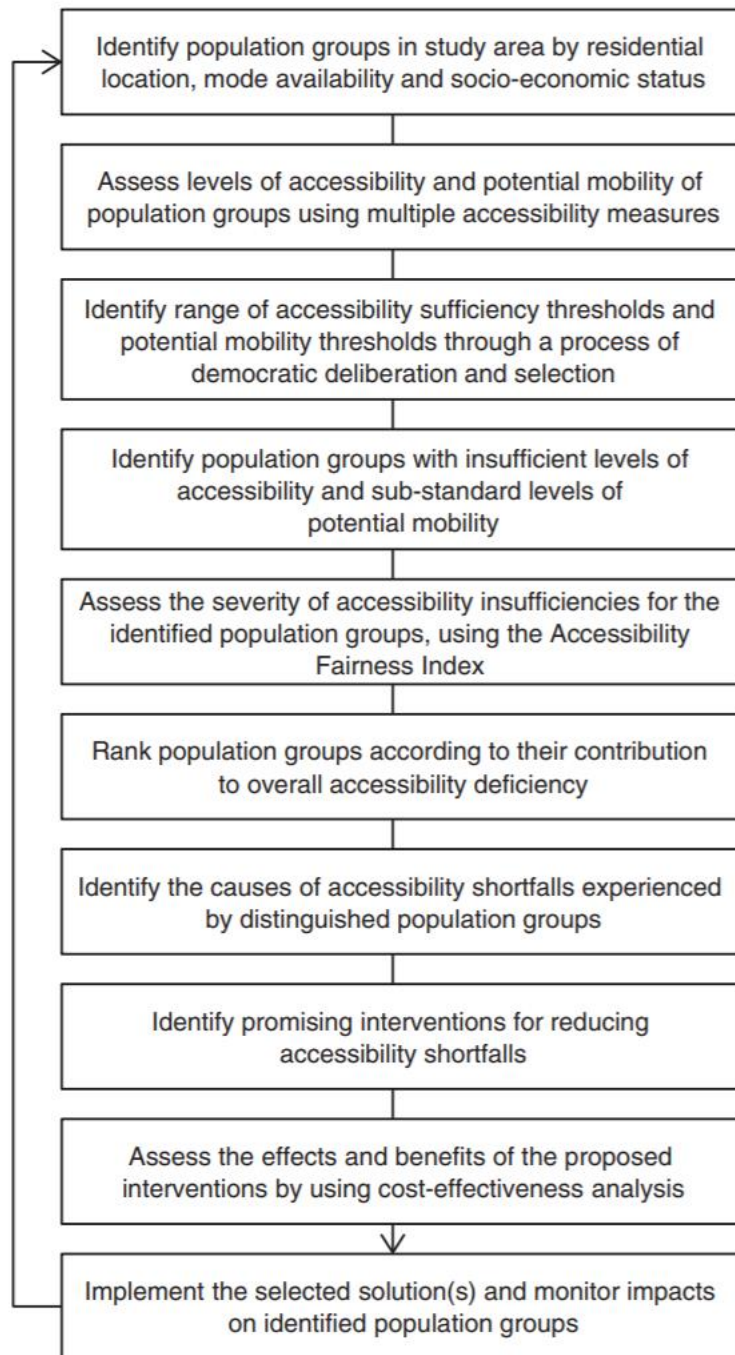
4.2 Case Study: Amsterdam, Netherlands

4.2.1 Background

In this case study, Karl Marten explores the fairness of the transport land use system in Feinstein’s *The Just City* ‘exemplary city’. The City region of Amsterdam was chosen as the location of study because “it provides employment and services to a much larger region and the City Region has held important responsibilities regarding the planning of

the transportation system in the entire area” (Martens 2017, 181). The case study applies the “rules of transportation planning based on principles of justice” (Martens 2017, 150) to Amsterdam’s transportation systems.

Figure 4-2 The Rules of Transportation Planning Based on Principles of Justice



Source: Martens, 2017

Figure 4-2 illustrates “a general approach to transportation planning based on principles of justice... a top-down technical approach will have to be complemented by a bottom-up participatory approach... forms of participatory decision-making” (Martens 2017, 173). “Not all the steps of the approach have been sufficiently developed so that they can be directly applied. But second, and more importantly, a full-fledged execution of all the steps would require the identification and ex ante assessment of transportation intervention seeking to address accessibility shortfalls in the Amsterdam region” (Martens 2017, 182). The study identified “the necessary sets [of] data on total population, population by income class, travel times to all surrounding zones, aerial distances between all zones, and assess ability levels for a range of travel time thresholds all at a zonal or other level of spatial aggregation... the six steps will lead to the identification of the population groups experiencing accessibility shortfalls in other words the analyses presented here result in the delineation of the transportation problem to be addressed through interventions in the transportation (and land use) system” (Martens 2017, 182-183).

4.2.2 Step 1: Population Groups

Marten explains the first step aims “to break up the overall population of our region into groups that may be expected to experience distinctly different accessibility levels... the division of groups may be further refined based on additional characteristics of persons such as travel related abilities household composition gender or ethnicity particularly if these attributes shape accessibility levels in a systematic way that goes beyond what can be explained by residential location mode availability and income” (Martens 2017,

183). It is important to note that “the division of groups... have to be based on data that is typically collected for a range of administrative purposes such as taxation or through population censuses and other surveys as well as restrictions... [on] data sources because of privacy considerations” (Martens 2017, 184). Due to privacy restrictions, the data in this study only accounts for “car-based and public transport-based accessibility” (Martens 2017, 185). The lack of bicycle data is a limit of the study and it is important to note that bicycling in the urban core of Amsterdam and bicycling combined with public transit is a popular mode of transport. The groups distinguished in the case study are “based on three characteristics: persons’ residential location, mode availability, and income level” (Martens 2017, 185). Again, due to data limitations, mode availability only refers to “persons with access to a car and persons with access to public transport services. For reasons of simplicity, it is assumed that the accessibility levels experienced by the former group (mode availability) is determined entirely by the road system. The underlying reasoning here is that the car provides superior accessibility in virtually all cases and that adding other transportation modes adds relatively little to the accessibility levels experienced by persons with continuous access to cars” (Martens 2017, 185). Marten makes this assumption based on a “study comparing travel times by car in public transport for the Netherlands” (Martens 2017, 185). This is a fair assumption to conclude in Sacramento, California as well illustrated in Figure 5-9.

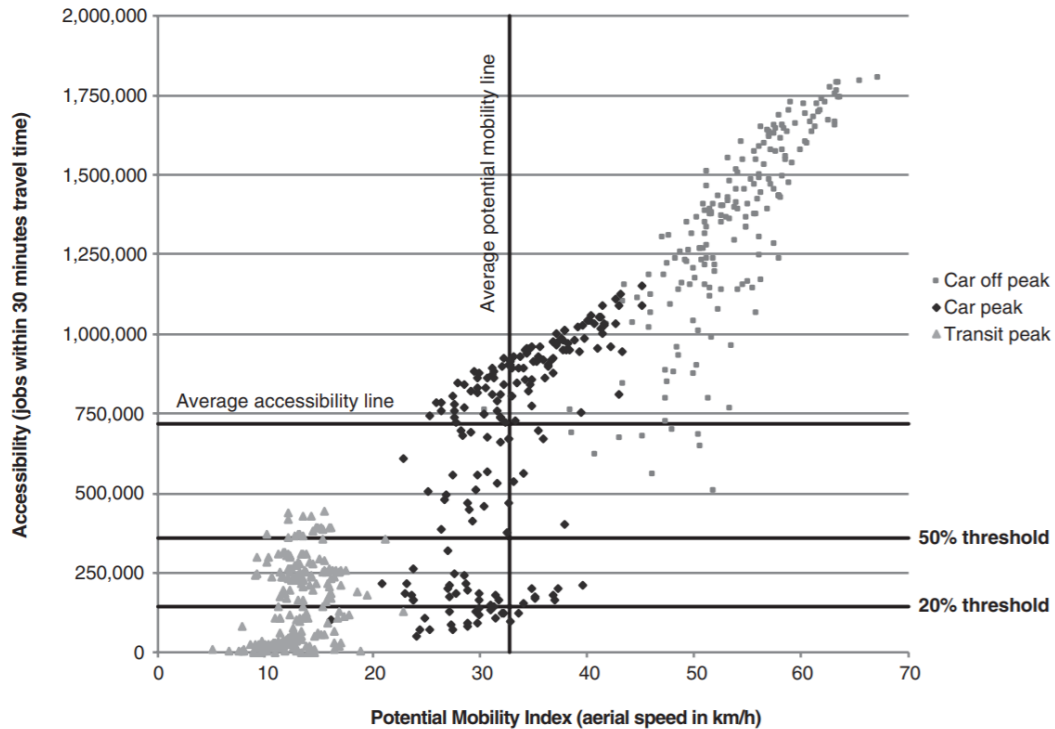
This study “also assume[s] that the accessibility levels experienced by most car-less households depends mostly on the quality of the public transportation system” (Martens 2017,186). Walking or bicycling are the other most common modes of transportation in

Amsterdam and Sacramento, but distance and time are extremely limited for these transport modes. It is fair to assume that if those modes were included in an accessibility analysis, they would face little competition to cars or public transportation. The study argues “that the level of income is a more appropriate indicator for a person’s mode availability, since it strongly correlates with access to a car” (Martens 2017, 187). Based on this, “it is expected that the low-income population groups will be more prone to experience accessibility shortfalls than population groups who can benefit from car-based accessibility” (Martens 2017, 188).

4.2.3 Step 2: Measuring Potential Mobility and Accessibility

To determine population groups accessibility levels, “it is desirable to measure accessibility to key destinations such as employment, shops, and health care services. The measurement of accessibility should...be conducted at various spatial scales. For instance, analyses could be conducted for travel time thresholds of 15, 30 or 45 minutes...Clearly...accessibility should be measured for different periods of the day and week as it typically varies across time due to congestion and variations in service provision” (Martens 2017, 189). Amsterdam’s “measurement of potential mobility and accessibility has been based on travel demand model” but the case study is limited to “only address accessibility to employment” (Martens 2017, 189). Twelve car-based accessibility analyses and six public transport-based accessibility analysis” were performed, resulting in a diagram illustrating accessibility thresholds for car and public transit potential mobility.

Figure 4-3 Levels of Mobility and Accessibility by Population Groups



Source: Martens, 2017

“The diagram shows the vast disparities in potential mobility and accessibility in the Amsterdam region, in spite of its relatively well-developed public transport system” (Martens 2017, 191). The diagram further illustrates that the transport-land use system delivers all groups assumed to be dependent on public transport have below-average potential mobility and accessibility levels (Martens 2017, 192). Rather, the graph “provides a powerful portrayal of the disparities between groups with and without access to a car... suggesting that interventions in the transportation system should first and foremost address the plight of population groups without access to a car” (Martens 2017, 192).

4.2.4 Step 3: Sufficiency Thresholds

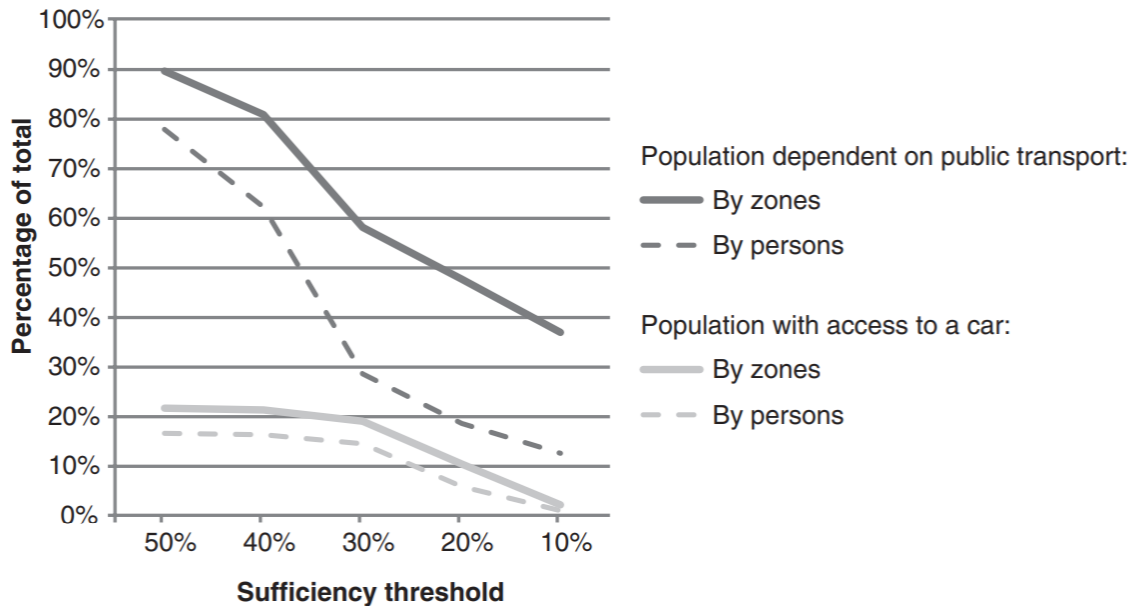
Transport Justice strongly emphasizes that “sufficiency thresholds should ultimately be the subject of democratic deliberation and selection” (Martens 2017, 194). The Amsterdam case study uses the average level of car based potential mobility in peak hours as the threshold for distinguishing groups entitled to improvements in the transportation system from groups that can claim no such entitlement” (Martens 2017, 195). Transportation planning, whether based on principles of justice or not, focuses on interventions in the transportation system; it is therefore of key importance to delineate in which cases interventions in the transportation system are warranted and in which case is not” (Martens 2017, 194-195).

4.2.5 Step 4: Population Groups Entitled to Accessibility Improvements

Martens states plainly that “all population groups falling below the accessibility sufficiency threshold and experiencing below average level of potential mobility belong to the set of groups potentially entitled to interventions in the transportation system” (Martens 2017, 195). This is very simply stated because accessibility is complex and multifaceted, so further analysis must be performed. It is important to note “that transportation planning based on principles of justice cannot be a simple cookbook approach to identify and address transportation problems” (Martens 2017, 196). In step four, Marten produces a graph depicting “share[s] of the population within accessibility level below the respective sufficiency thresholds for accessibility to employment a 30-

minute travel time threshold accumulative opportunity measure and during peak hours” (Martens 2017, 197).

Figure 4-4 Populations dependent on Public Transport and Car



Source: Martens, 2017

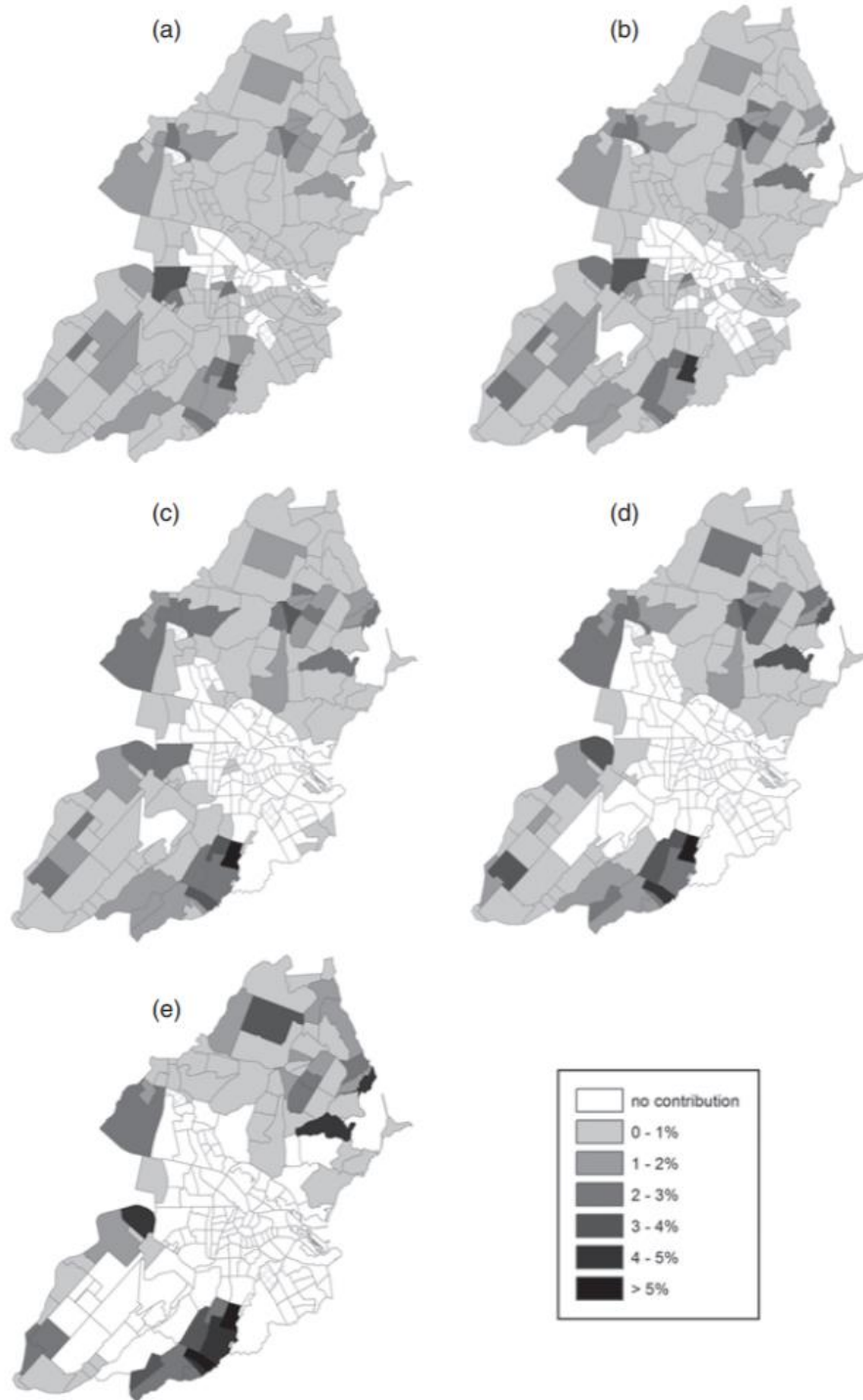
The graph in “Figure 9.3 [4-4 above] powerfully depicts the car provides a high level of accessibility in the Amsterdam context even for persons living on the periphery... The situation is clearly fundamentally different for persons relying on public transport as their main mode to access places. A substantial share of this population experiences low levels of accessibility throughout most of the day...[because] the accessibility levels provided by the public transport system during off peak hours is at best comparable to the levels during peak hours” (Martens 2017, 197). It can be assumed that the accessibility levels for this share of population experiences even lower accessibility levels at night and on weekends “when public transport services are reduced or not available at all” (Martens 2017, 197).

4.2.6 Step 5: Assessing the Severity of Accessibility Deficiency

So far, the steps have resulted in transit-dependent populations and populations with access to a car during peak hours being prone to experience accessibility shortfalls (Martens 2017, 197). For transit dependent population groups, “the spatial pattern of accessibility deficiency changes fundamentally with a decrease in the sufficiency threshold” (Martens 2017, 198). The only transit dependent population groups that have a sufficient level of accessibility are groups residing directly in and around the city center of Amsterdam” (Martens 2017, 198). “These population groups obviously benefit from the high quality of the public transport system in the urban core as well as from the proximity to jobs in both the city center” (Martens 2017, 198). *Vis a vi*, accessibility deficiency remains a primarily (sub)urban phenomenon in the Amsterdam region” (Martens 2017, 199).

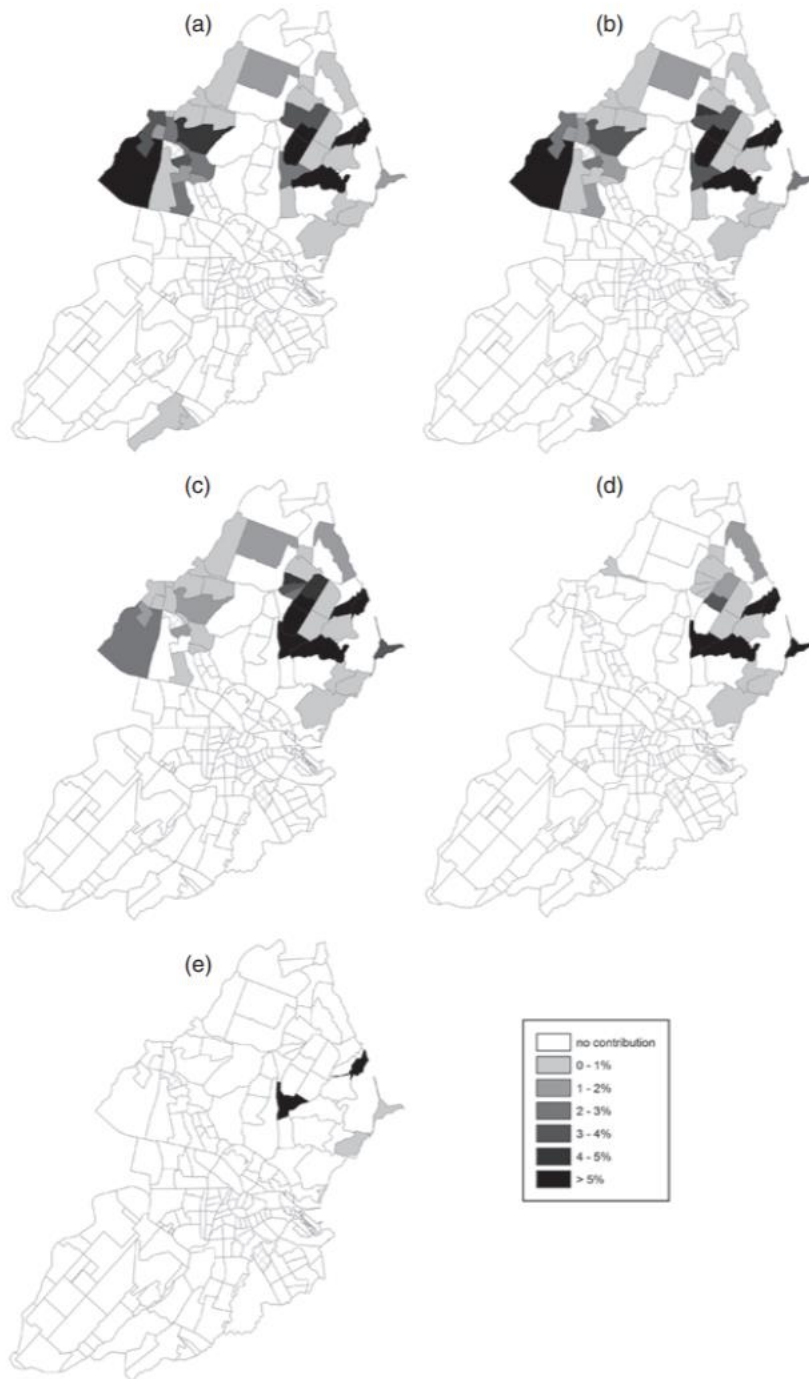
“A relatively small number of population groups experience accessibility” shortfalls due to car-based accessibility deficiency (Martens 2017, 201). “The spatial pattern of accessibility deficiency for the groups benefiting from car-based accessibility is quite distinct from the pattern observed for the transit dependent population groups. Figure 4-5 and Figure 4-6 compare the accessibility deficiency spatial patterns of transit-dependent population groups and population groups that benefits from car access.

Figure 4-5 Accessibility Deficiency Among Transit Dependent Population Groups



Source: Martens, 2017

Figure 4-6 Accessibility Deficiency Among Population Groups with Access to a Car



Source: Martens, 2017

These maps further illustrate the high levels of accessibility that population groups with car access experience compared to the low accessibility that population groups that are transit-dependent experience.

When accessibility deficiency is analyzed across the entire population, ignoring population groups access to vehicle or not, the results show that for this case study “the entire burden of accessibility deficiency is [still] carried by the population groups without access to a car” (Martens 2017, 206).

4.2.7 Step 6: Prioritizing Population Groups

Each step so far in “transportation planning based on principles of justice...each analysis generates a different pattern of access ability deficiency and suggest that a different set of groups are experiencing the impacts of accessibility deficiency in the region” (Martens 2017, 206). Different “way[s] of measuring accessibility will result in a distinct pattern of contributions to overall accessibility deficiency... the moral significance of the way in which population groups are distinguished and access ability is measured becomes increasingly apparent the more the analysis proceeds towards feeding the democratic decision-making process” (Martens 2017, 207-208).

The analysis of the Amsterdam case study “has been conducted of the average contribution of each population group to total accessibility deficiency based on the data at hand: population groups as defined by income levels; accessibility as measured at the zonal level; the full range of accessibility measurements; and the entire set of

sufficiency thresholds. The results of this analysis are quite complex in nature. For each sufficiency threshold a different ranking of population group emerges” (Martens 2017, 208). Marten then requires additional analyses “based on twelve different ways of measuring car-based accessibility (including peak and off-peak measurement) and six different ways of measuring transit-based accessibility (excluding off-peak measurement). The average contribution to accessibility deficiency by population group has been calculated by adding up the contribution by group to each type of accessibility measurement, divided by the number of accessibility measurements” (Martens 2017, 206-207). This is in no means the definitive way to identify population groups to prioritize, “but it does give a grasp of the extent to which a particular population group may be affected by the accessibility deficiency in a region under various circumstances” (Martens 2017, 207).

The results of the Amsterdam case study suggest “that more is needed to bring the accessibility levels of population groups with and without access to a car above the sufficiency threshold (however defined). This may well imply a further improvement of the bus lane a higher priority for buses at intersections or a higher frequency of buses throughout a larger part of the day” (Martens 2017, 209). These are different types of transportation planning interventions that Martens has discussed previously.

“Improvements are also warranted to address the situation of persons with car access as they to experience a substandard accessibility level, although the accessibility shortfall is much less severe than for the transit dependent population” (Martens 2017, 209). The analysis is capable of identifying population groups to prioritize in each zonal

group, and even though the prioritized population groups in zonal groups will differ, “interventions in the transportation system should be inclusive in nature, at least potentially serving all population groups, i.e., groups with and without access to a car at the same time” (Martens 2017, 209).

4.3 Key Takeaways

“The application of transportation planning based on principles of justice to the Amsterdam region...has resulted in a preliminary identification of population groups entitled to improvements in accessibility through interventions in the transportation system” (Martens 2017, 213). The analysis above points out the specific limitations of public transit as conventionally delivered. A new approach is needed where those without vehicles can access them at least temporarily when needed

The Amsterdam case study further emphasizes that not only is the technical analysis involved and important, but again emphasizes the political discourse that must be involved. Marten stresses the importance of “a transparent and well-structured democratic deliberation and selection. Transportation planning cannot move forward without being fed from the initial stages onward by a democratic process of decision making” (Martens 2017, 212). This is referring to the top-down, bottom-up approach mentioned previously in this study. Persons and their lived experiences must be at the forefront of analyzing the fairness and accessibility deficiencies of a transportation system. Political discourse and technical analyses must be looked at together to

complete the full picture to address accessibility deficiencies and fairness of a transportation system.

5. Background to Study Area

5.1 Transportation Network

5.1.1 Roadway Network

The City of Sacramento's roadway network consists of U.S. Interstates, California State highways, and city streets (arterial, collector, and local streets). Personal vehicle travel dominates use of the roadway network. Figure 5-1 depicts the roadway hierarchy.

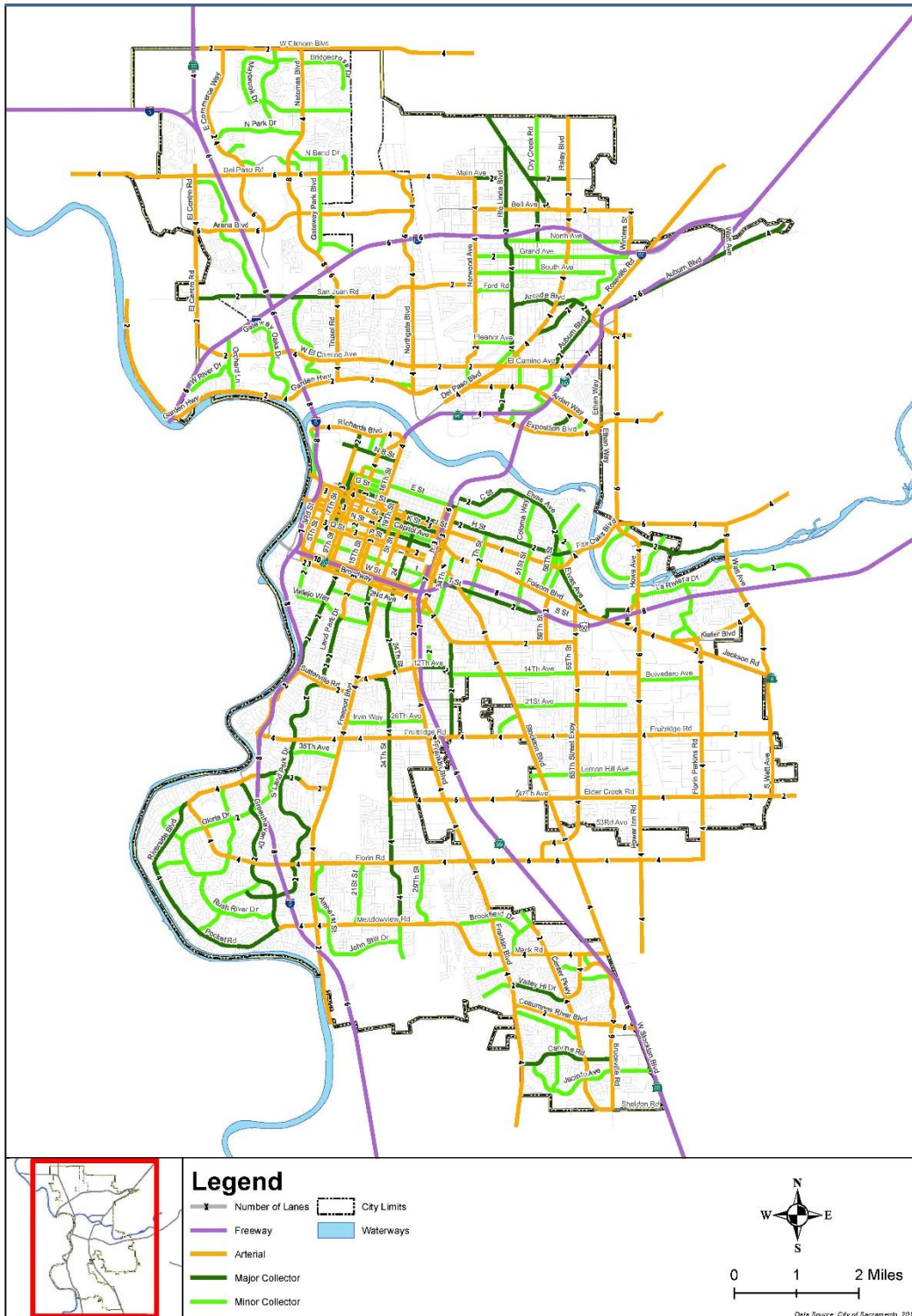
5.1.2 Bicycle Network

Figure 5-2 depicts the bicycle network. It consists of shared-use paths (Class I), bike lanes (Class II), and shared roadways termed "sharrows" (Class III).

5.1.3 Transit Network

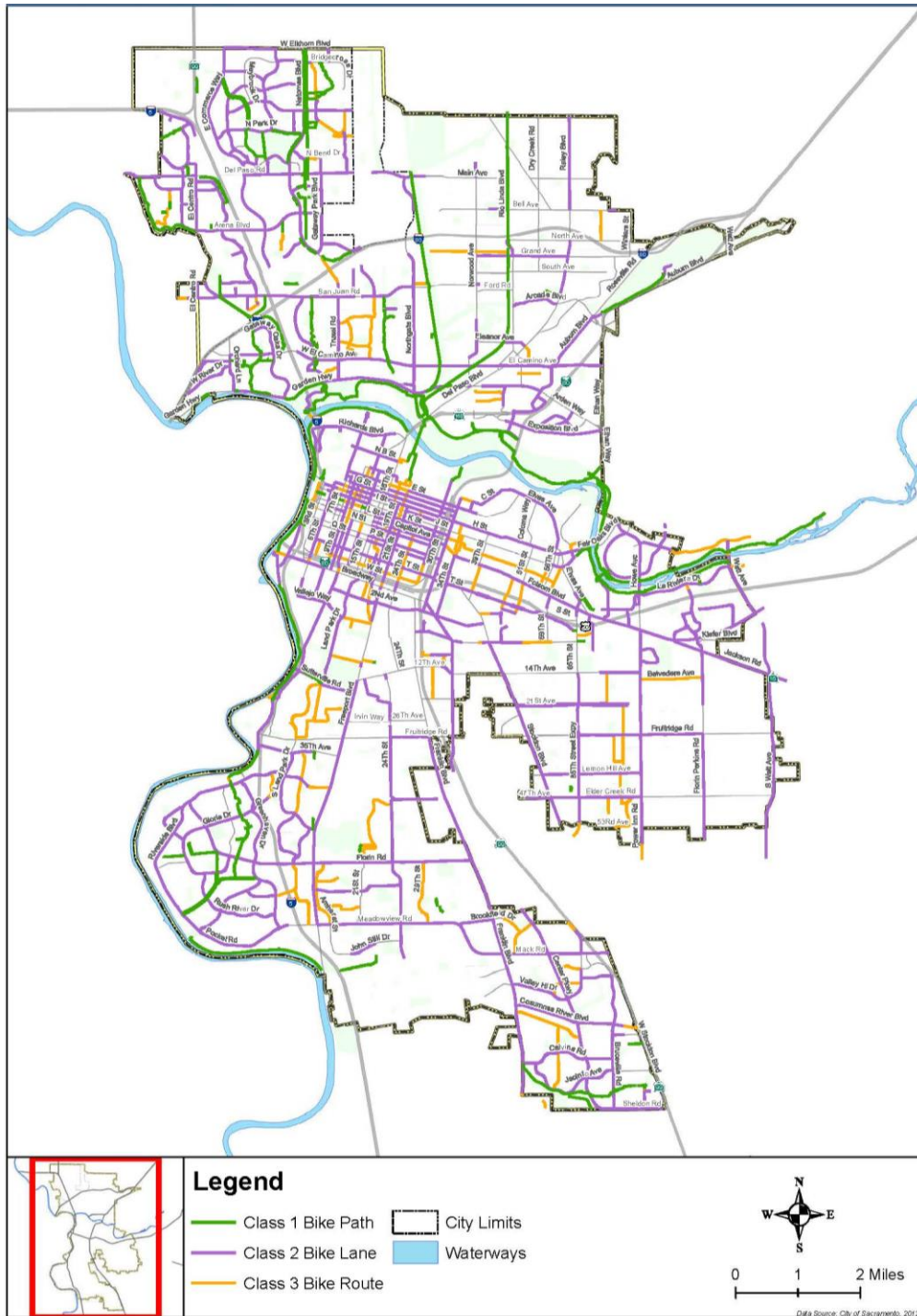
The City of Sacramento is served by local, regional, and interregional transit. Sacramento Regional Transit (Sac RT) provides local bus and light rail services. Greyhound, Megabus, and Amtrak provide regional and interregional services to the City. In addition, Sac RT operates 18 Park-and-Ride lots that enable commuters to access regional public transit by automobile (City of Sacramento, 2015). Figure 5-3 depicts the existing transit network.

Figure 5-1 Roadway Classification and Lanes



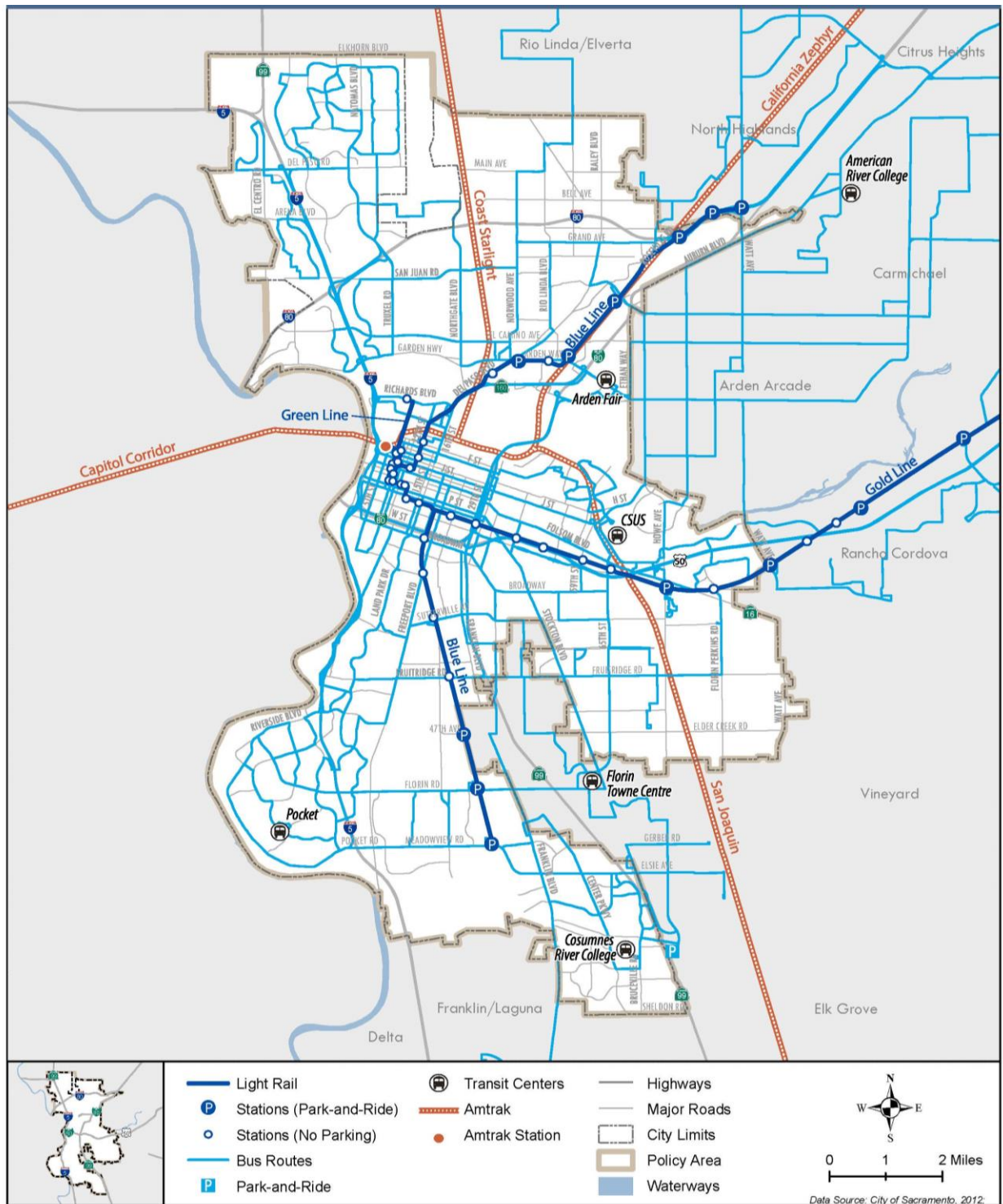
Source: City of Sacramento, 2015

Figure 5-2 Existing Bicycle Facilities



Source: City of Sacramento, 2015

Figure 5-3 Existing Transit System



Source: City of Sacramento, 2015

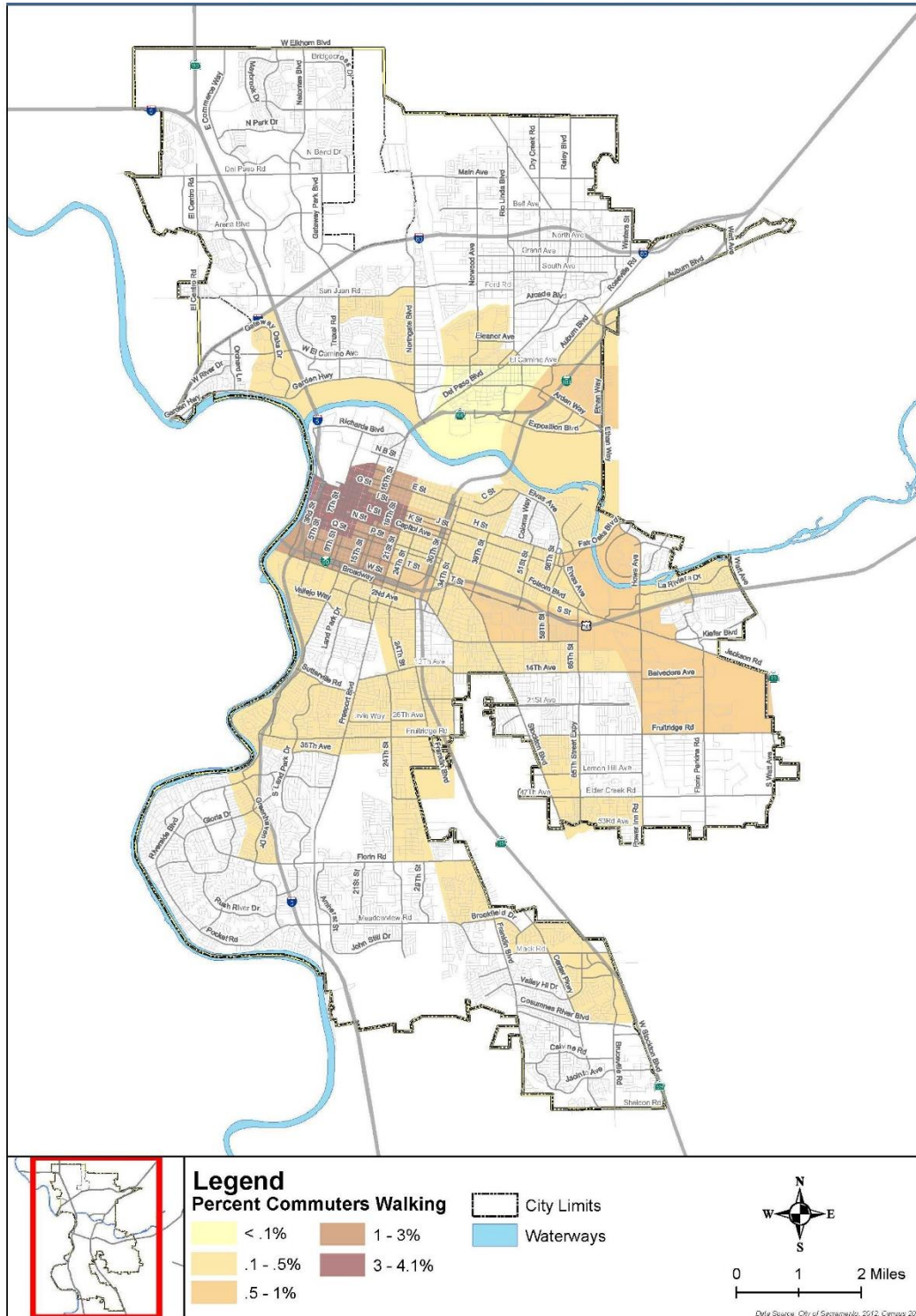
5.1.4 Pedestrian Activity

The Sacramento General Plan explains that “pedestrian travel is of prime importance to the City, and pedestrian facilities, such as enhanced crosswalks and pedestrian count-down signals, new sidewalks, traffic calming measures, and streetscape enhancements are continuously being implemented in the City” (City of Sacramento, 2015, 3-41).

Figure 5-4 depicts the intensity of pedestrian commuting in parts of the Metro area.

Clearly there is a concentration of pedestrian activity in the downtown core and areas adjacent to the downtown.

Figure 5-4 Commuters Walking to Work



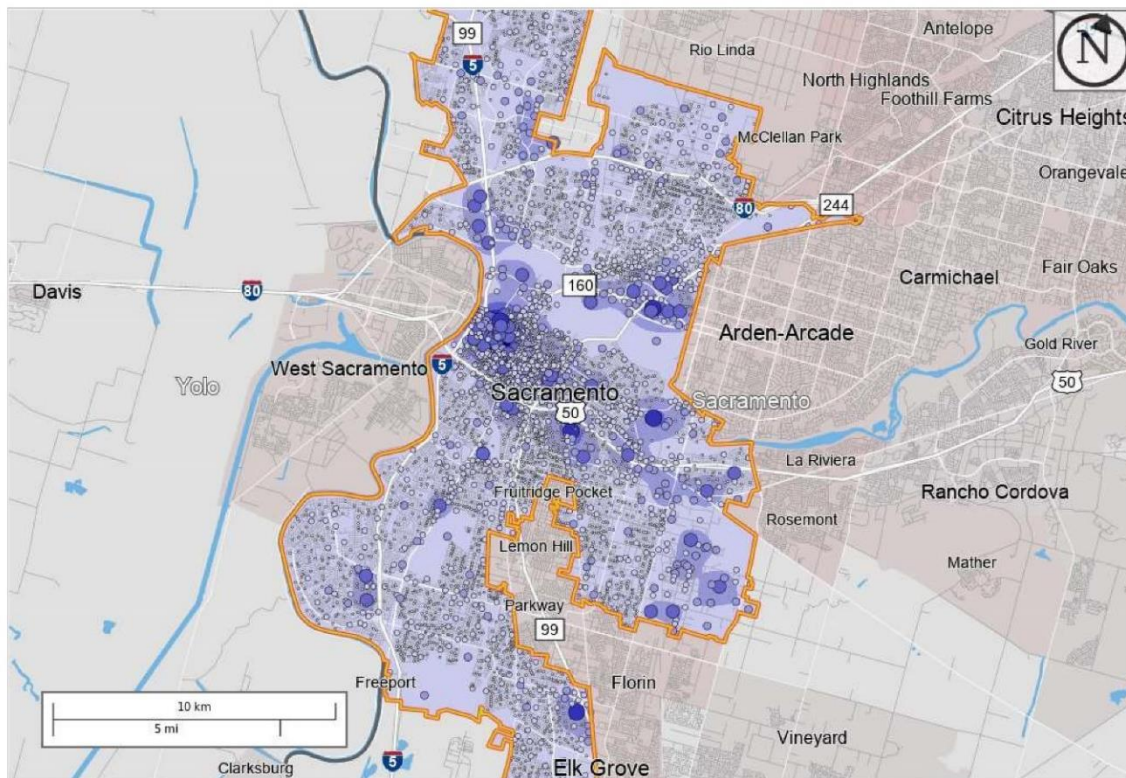
Source: City of Sacramento, 2015

5.2 Jobs and Commuting

5.2.1 Distribution of Job Centers

Downtown Sacramento is the central business district in the city because it has major job clusters. Ideally, jobs would be located in close proximity to one’s home. Figure 5-5 depicts the concentrations of jobs across the Metro area. The transportation networks for various modes are consistent with job locations.

Figure 5-5 Counts and Density of All Jobs in Work Selection Area in 2018



Map Legend

Job Density [Jobs/Sq. Mile]	Job Count [Jobs/Census Block]
■ 5 - 3,889	● 1 - 15
■ 3,890 - 15,544	● 16 - 230
■ 15,545 - 34,967	● 231 - 1,164
■ 34,968 - 62,161	● 1,165 - 3,677
■ 62,162 - 97,124	● 3,678 - 8,976
	Selection Areas
	★ Analysis Selection

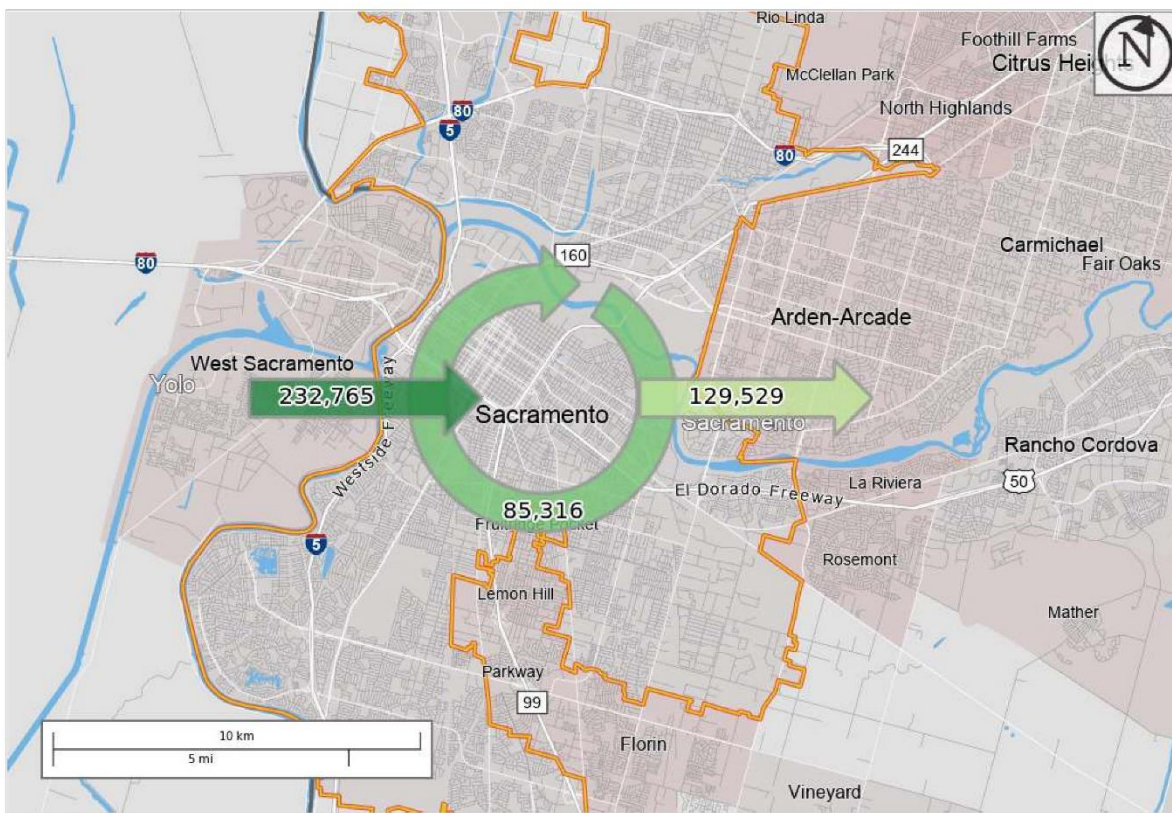


Source: US Census 2018

5.2.2 Origins and Destinations of Workers

Figure 5-6 depicts the inflow and outflow of workers. The figure demonstrates that nearly twice as many people commute into Sacramento for work as those who commute outside the City for work. This reflects the role of the City as the state capital. A modest 19% of workers live and work within the Metro area.

Figure 5-6 Inflow/Outflow Counts of All Jobs in Sacramento Region in 2018



Map Legend

Selection Areas

- Analysis Selection

Inflow/Outflow

- Employed and Live in Selection Area
 - Employed in Selection Area, Live Outside
 - Live in Selection Area, Employed Outside
- Note: Overlay arrows do not indicate directionality of worker flow between home and employment locations.



Source: US Census 2018

5.2.3 Commute Time

Table 5-1 states the time that it takes people to commute to work on average, by all available modes of transportation. It takes about 35% of the working population over 30 minutes to travel to work. The mean travel time to work for the working population is about 26 minutes.

Table 5-1 Travel Time to Work by Gender

Sacramento city, California			
	Total	Male	Female
Label	Estimate	Estimate	Estimate
Workers 16 years and over who did not work from home	217,090	112,143	104,947
Less than 10 minutes	8.0%	7.8%	8.2%
10 to 14 minutes	13.8%	13.1%	14.6%
15 to 19 minutes	17.4%	17.6%	17.2%
20 to 24 minutes	18.3%	17.5%	19.2%
25 to 29 minutes	6.8%	6.6%	7.0%
30 to 34 minutes	16.9%	17.1%	16.8%
35 to 44 minutes	5.6%	5.3%	5.9%
45 to 59 minutes	5.9%	6.2%	5.5%
60 or more minutes	7.3%	8.9%	5.6%
Mean travel time to work (minutes)	26.2	27.5	24.9

Source: US Census 2019

Table 5-2 breaks down the travel time by auto drive-alone, carpool, and public transportation. It is much faster to commute to work by driving alone or carpooling than commuting by public transportation. It takes 60 or more minutes for 36.4% of people commuting by public transportation to reach their destination compared to 6% by auto and 10% by carpool. This helps explain why people choose to drive to work if they have access to a car. Furthermore, for those dependent on public transportation, their accessibility will be much lower than people with access to a private vehicle.

Table 5-2 Travel Time by Commute Mode

Sacramento city, California				
	Total	Car, truck, or van -- drove alone	Car, truck, or van -- carpooled	Public transportation (excluding taxicab)
Label	Estimate	Estimate	Estimate	Estimate
Less than 10 minutes	8.0%	7.2%	7.5%	0.7%
10 to 14 minutes	13.8%	14.0%	12.6%	1.6%
15 to 19 minutes	17.4%	18.0%	15.9%	5.5%
20 to 24 minutes	18.3%	19.4%	16.7%	8.6%
25 to 29 minutes	6.8%	7.0%	7.9%	4.3%
30 to 34 minutes	16.9%	17.3%	16.5%	22.3%
35 to 44 minutes	5.6%	5.6%	6.2%	9.2%
45 to 59 minutes	5.9%	5.6%	7.2%	11.5%
60 or more minutes	7.3%	5.9%	9.6%	36.4%
Mean travel time to work (minutes)	26.2	25.2	28.8	53.0

Source: US Census 2019

5.2.4 Commute Modes

Like most other metropolitan areas in the US, the choice of transportation to work

heavily favors the automobile. As Table 5-3 shows, about 85% of commuters travel by

car as their means of transportation and three-quarters drive alone. This has

implications for equity if there are some members of the community who cannot afford

personal transportation.

Table 5-3 Means of Transportation to Work by Gender

Sacramento city, California			
	Total	Male	Female
Label	Estimate	Estimate	Estimate
Workers 16 years and over	229,953	118,786	111,167
Car, truck, or van	84.9%	84.4%	85.3%
Drove alone	74.4%	74.5%	74.4%
Carpooled	10.4%	10.0%	10.9%
<i>In 2-person carpool</i>	7.8%	7.4%	8.2%
<i>In 3-person carpool</i>	1.6%	1.6%	1.5%
<i>In 4-or-more person carpool</i>	1.1%	1.0%	1.2%
Public transportation (excluding taxicab)	3.3%	3.3%	3.4%
Walked	2.8%	2.8%	2.8%
Bicycle	1.9%	2.2%	1.5%
Taxicab, motorcycle, or other means	1.5%	1.7%	1.4%
Worked from home	5.6%	5.6%	5.6%

5.3 Sacramento Case Study

5.3.1 Background

Housing and land use impacts transportation and transportation impacts housing and land use. This case study looks at historical and contemporary race-based patterns of residential segregation connected to unsustainable loans and the housing crisis. It outlines Sacramento’s history of inaccessibility to destinations, jobs and opportunities for low-income, minority groups and how they were segregated. It sets the stage for the historical context of Sacramento’s housing and transportation market and motives for current day analysis.

5.3.2 Key Takeaways:

The effects of discriminatory policies still shape Sacramento's housing and transportation network today. "Inequitable effects of the mortgage meltdown are concentrated in non-white communities and also demonstrate how inequities remain rooted in long-standing patterns of housing discrimination that shaped segregated space. These historical practices of market intervention have served to reinforce a social, economic and political segmentation that reaffirm spatial distance" (Hernandez 2012, 238). "New Deal finance policies institutionalized a social and spatial order in our cities that produced a segregated urban core." (Hernandez 2012, 238). Federal regulatory policy makers "linked race to asset value [to] justify the use of race covenants and mortgage red lining as an economic imperative- an imperative that steered capital flows away from the nonwhite urban core under the guise of risk management" (Hernandez 2012, 238-239).

5.4 Analysis of Study Area

5.4.1 Accessibility Study

This study measured accessibility in downtown Sacramento, California using a map-based approach. The maps in this series measure the distance someone can travel away from a specified location in a certain period of time, using different modes. The process that created these maps also produces maps for the opposite direction and for different times of day.

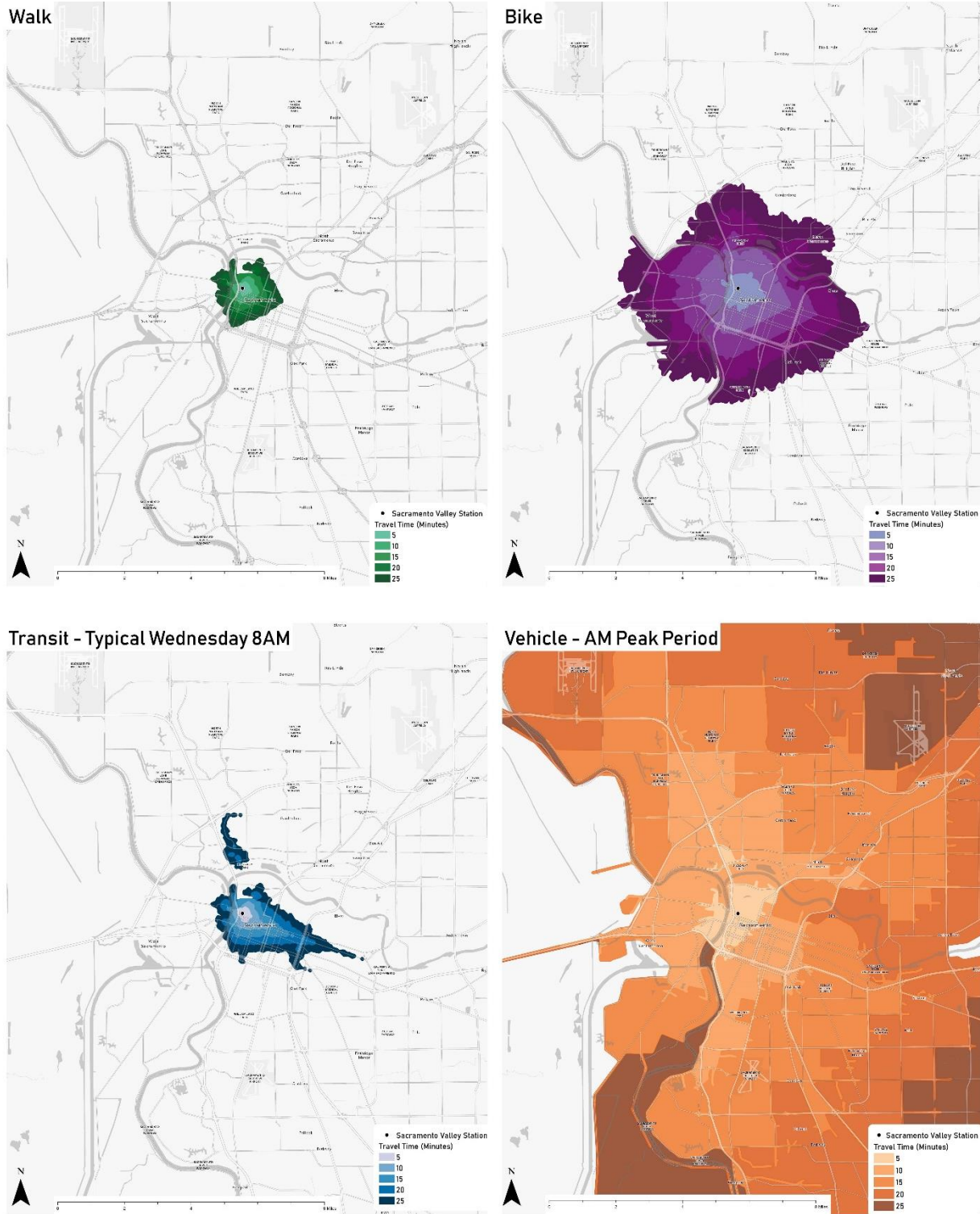
Maps were created using travel time isochrones by travel mode in ArcGIS Pro based on Open Street Map (OSM), general transit feed specification (GTFS), and regional travel demand model data from the Sacramento Area Council of Governments (SACOG). The travel times are estimated based on average walking and bicycling speeds of 3 and 9 miles per hour, respectively. Transit speeds were obtained from the GTFS data and vehicle speeds were obtained from the peak period traffic assignments from the SACOG travel demand model. These isochrones are effective in quickly communicating the results that are easy to understand by diverse audiences. To help demonstrate modal differences, we produced small multiple maps of each mode's travel time isochrones showing the distance one can travel to/from the Sacramento Valley Station, which is a key destination in downtown Sacramento for gaining access to the rest of the region. The maps show the isochrones in five-minute increments (from five to twenty-five minutes) and are complemented by the public transit isochrones during the morning peak hour while recognizing that shifts occur by time of day depending on changes in transit service throughout the day.

The specific modes studied in the model include bicycle, walking, public transit [with wheelchair], and automobile. In this model, the Sacramento Valley Station is the location that people are traveling away from or to, so the model can be used to represent both a location-based and person-based perspective. The ***person-based model*** measures the distance one can travel away from a location in a certain amount of time, in this case the Sacramento Valley Station. The ***location-based model*** shows

the area from which people can access the desired destination within a certain amount of time.

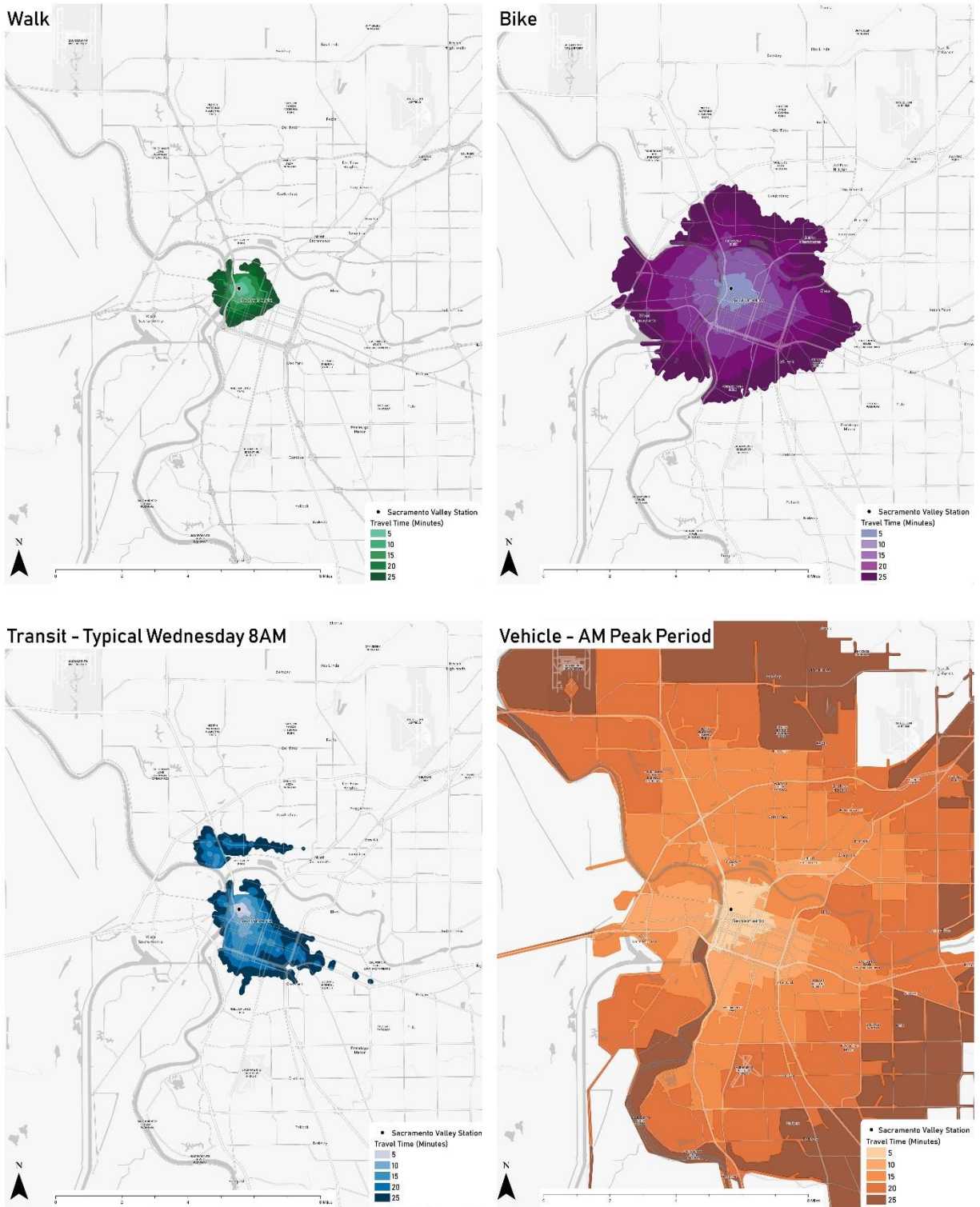
To demonstrate the importance of the *person-based model* type of accessibility analysis and mapping is through recognition of substantial difference in travel time isochrone sizes across modes. Individuals with access to a vehicle have a much greater distance they can travel within the same amount of time than the other modes studied. This difference is so great, it raises questions about how to create more equitable travel outcomes for those who do not own private vehicles, especially in the lower income and lower density neighborhoods that surround downtown Sacramento. Conventional transportation planning approaches to improve access have focused on increasing transit service. As the small multiple maps show, the transit isochrones cover an area smaller than the bicycle isochrones. Frequent transit service is generally not feasible or productive in low density areas. For the residents of these areas, accessibility would be most improved by having access to higher speed vehicles when they need to make a trip. This can be accomplished by developing and providing electric bike/scooter or car share systems and supporting on-demand ride-hailing services. Absent the use of multi-modal accessibility mapping, this type of recommendation might not be considered. Figures 5-7 and 5-8 compare accessibility by mode from the Sacramento Valley Station.

Figure 5-7 Accessibility from Sacramento Valley Station by Mode



Source: Fehr & Peers, Meredith Milam 2020

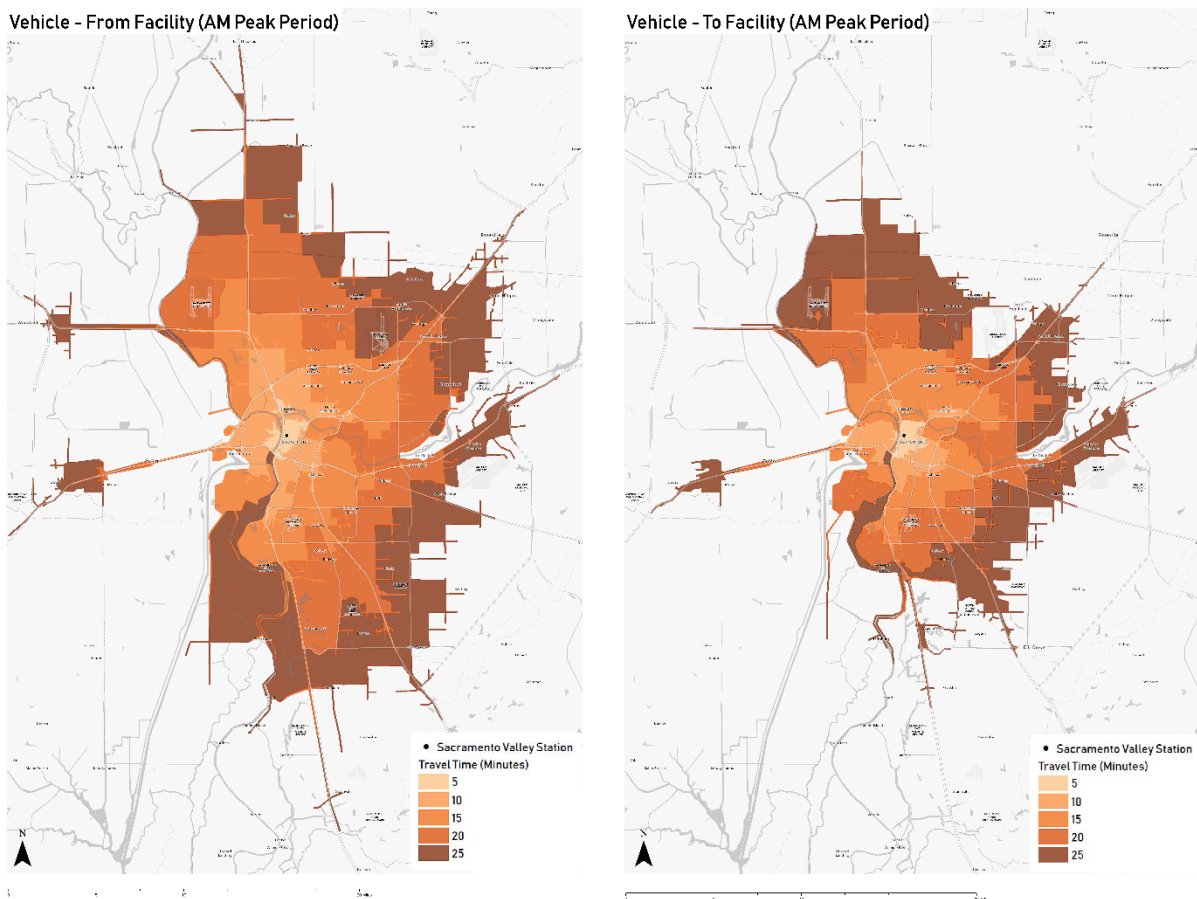
Figure 5-8 Accessibility to Sacramento Valley Station by Mode



Source: Fehr & Peers, Meredith Milam 2020

Figure 5-9 illustrates private vehicle accessibility in the Sacramento region. Individuals with access to private vehicles have a widely different experience because they can access jobs, other modes of transportation, and a much larger range of opportunities.

Figure 5-9 Vehicle Accessibility to and from Sac Valley Station



Source: Fehr & Peers, Meredith Milam 2020

5.4.2 Equity Analysis

Isochrone on small multiple maps compare the four modes of transportation accessibility (walk, bike, transit, personal vehicle) with: percent of population by block group that is not white, percent of population by block group that is Hispanic/Latino, and

percent of population by block group that is below the poverty threshold. Each analysis uses the Sac Valley Station, as the node for downtown Sacramento which serves as the central business district and major job center for the metropolitan area.

5.4.2.1 Hypothesis:

Traditionally, transportation planning solutions to improve quality of life and opportunities for low-income and “persons-of-color” (POC) communities is to provide them with transit service. The Sac Valley Station is the major mobility hub for the region and has a range of mode options and distances one can travel. The demographic maps show that the low income and POCs are distributed and concentrated in the outer boundaries of the City. Figure 5-10 shows the areas with the highest concentration of low income and non-white populations.

It is important to understand the populations that are commuting by various modes because, as Table 5-4 illustrates, there are nuances between race and ethnicity and commute mode. POCs are the highest percentage of public transportation users. White and Asian populations have the highest percentage of commuters by private vehicle. However, POCs are distributed in the outer areas where transit access is limited as Figure 5-7 and Figure 5-8 show.

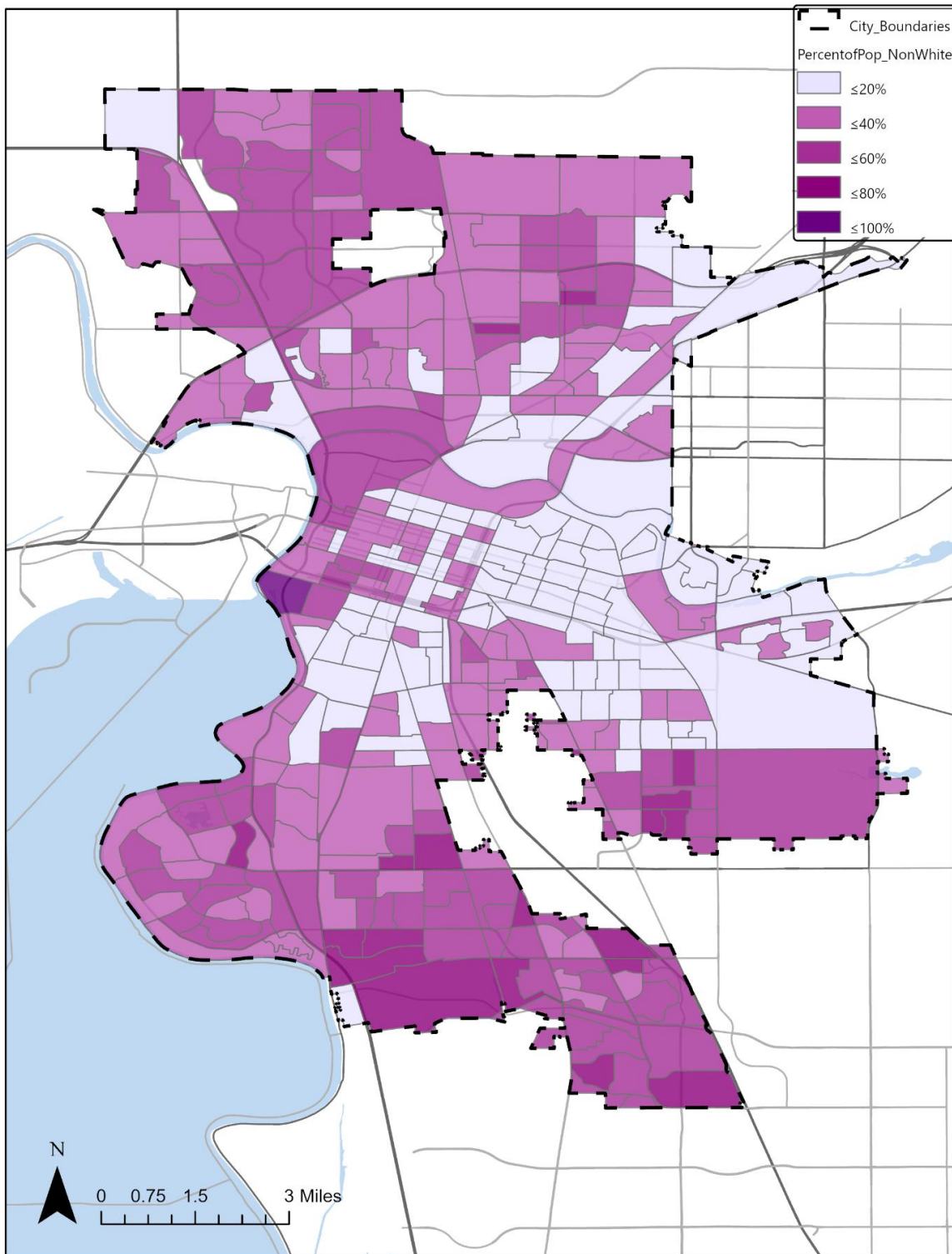
Table 5-4 Commute Mode by Race and Hispanic or Latino Origin

Sacramento city, California				
	Total	Car, truck, or van -- drove alone	Car, truck, or van -- carpooled	Public transportation (excluding taxicab)
Label	Estimate	Estimate	Estimate	Estimate
One race	94.1%	94.3%	92.3%	93.1%
<i>White</i>	49.7%	49.7%	39.6%	45.9%
<i>Black or African American</i>	11.9%	11.3%	11.3%	24.1%
<i>American Indian and Alaska Native</i>	0.7%	0.7%	1.0%	0.6%
<i>Asian</i>	18.2%	18.5%	23.2%	14.4%
<i>Native Hawaiian and Other Pacific Islander</i>	1.8%	2.0%	1.3%	0.5%
<i>Some other race</i>	11.9%	12.1%	16.0%	7.7%
Two or more races	5.9%	5.7%	7.7%	6.9%
Hispanic or Latino origin (of any race)	27.6%	28.2%	35.1%	19.9%
Non-Hispanic	72.4%	71.8%	64.9%	80.1%
White alone, not Hispanic or Latino	36.6%	36.1%	24.8%	36.9%

Source: US Census 2019

Figure 5-10 reveals that there are greater concentrations of White populations in downtown Sacramento and in eastern Sacramento. Non-white populations are concentrated on the outskirts near the City’s boundaries. This shows the spatial disparities that POCs experience living further away from the main job centers.

Figure 5-10 Percent of Population by Block Group Non-White



Source: US Census 2019

Figure 5-11 displays areas where higher concentrations of the population are below the poverty threshold (\$15,000). It is essential to compare Figure 5-10 and Figure 5-11 because they show that where higher concentrations of POCs live have higher percentages of the population that are below the poverty threshold. Households that are below the poverty threshold most likely do not have access to a vehicle. It is expensive to own a vehicle because it requires gasoline or electricity, maintenance, insurance, and other fees. Higher income households have access to private vehicles, whether that means they own one, or they have the money to obtain access to one.

Based on the maps and tables, POCs have lower access to private vehicles, which is the essential mode in Sacramento given the low-density land use context. This means that they have to rely on biking, walking, or transit. They cannot afford to live close to downtown Sacramento (i.e., the job, economic, entertainment, healthcare, and government center for the region). So, when analyzing their distribution compared to the downtown activity center there is a clear disconnect between these communities and this desirable destination for engaging in the economy and society. The maps in Figure 5-7 and 5-8 show that the footprint of these modes is very small because of the limited speeds and quality of service for transit. They cannot access job/activity centers or the transfer station if they do not own a vehicle. POCs and households under the poverty threshold, therefore, have lower transportation accessibility, and a more inequitable transportation system. Figure 5-12 shows how accessible public transit is by travel time isochrones in the Sacramento Area during the morning peak hour. POCs generally live in areas with long travel time access by public transit.

Figure 5-11 Percent of Population by Block Group that is Below the Poverty Threshold

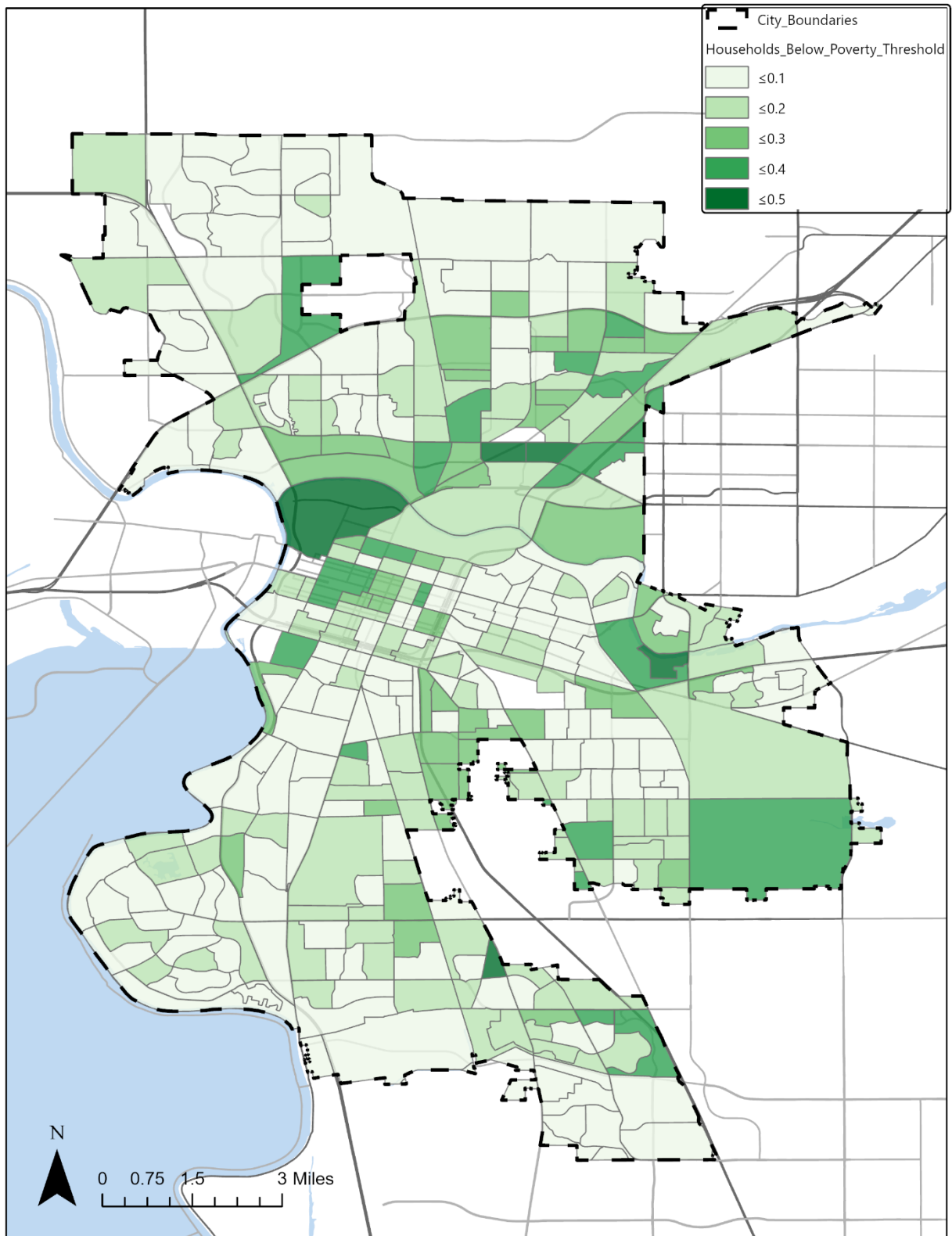
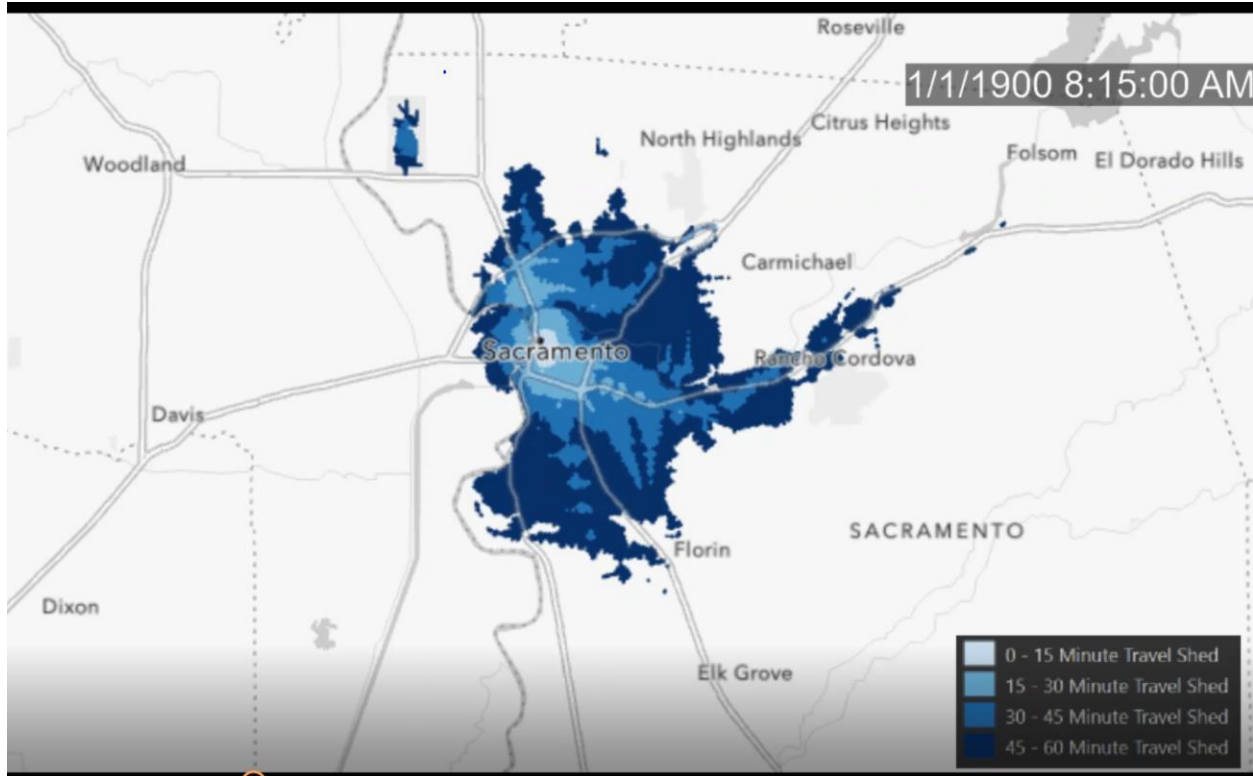


Figure 5-12 Peak Travel Time Isochrones by Public Transit in the Sacramento Area



5.5 Considerations

- The accessibility and equity maps show that the current provision of transit service for low-income populations and POCs does not improve their access to job centers or opportunities. Further, expanding conventional transit systems is expensive and has not proven to be effective in improving accessibility in a land use context like Sacramento's.
- This is a case study, so community input was not included in the analysis.
 - In practical application, community engagement should always be included in the equity analysis. The community's input can help shape the alternative solutions to traditional transportation planning.

5.6 Potential Solutions:

To improve accessibility within a land use context like Sacramento's, people need access to much higher travel speeds. This can be accomplished through the introduction of sustainable yet appropriate means of sharing smaller vehicles for both entire trips and connections to the areas transit system. These alternatives include the following:

- Provide (electric) vehicle carshare and place carshare vehicles in neighborhoods with higher concentrations of low-income populations and POCs.
- Increase the distribution of e-scooters and e-bikes, which can increase average travel speeds of conventional bicycles from 9 or 10 mph to 15 mph.
- Educate community members about potential carpooling opportunities through app-based solutions such as Waze Carpool.

Communication technologies are readily available to aid in the adoption of these novel ideas. City officials would need to coordinate the adoption and operation of these alternatives.

Other more long-term solutions could include the following:

- Fundamentally altering the intensity of land use and realigning them along corridors that transit serves well.
- Expanding affordable housing opportunities for POCs and low-income household in the highly accessible areas of the City.

6. Conclusion

A GIS spatial analysis of accessibility and equity combined with community input can provide planners with a more complete picture of how the transportation system serves different population groups and areas. By measuring accessibility by mode and mapping it with travel time isochrones, planners can engage a community to assess their expectations for making modifications to provide a fair and just transportation system. Alternative solutions for access to transportation and approaching equity are not a “one size fits all” model. To measure accessibility, all available transportation modes should be analyzed at AM and PM peak periods on a weekday, at a minimum. To assess equity, the accessibility mapping should be combined with key factors such as income, race and ethnicity, transit dependency to understand the distributional disparities in access that may exist. Distribution patterns of POCs and low-income populations in Sacramento combined with current modal accessibility severely limits their job and activity opportunities.

In Sacramento, getting people access to vehicles would make a substantial improvement in equity for POCs and low-income populations. Making these vehicles electric and shared can reduce the cost to access vehicles (i.e., only paying on a per trip basis) and minimize the environmental impacts of their use. Additional alternatives such as implementing e-bike/e-scooter share and informing people of carpooling options could also increase accessibility at low costs with minimal environmental

impacts. While this conclusion was drawn specifically for Sacramento, it is transferable to similar land use contexts in the U.S.

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