Transportation Cordon Pricing in the San Francisco Bay Area:

Analyzing Equity Implications for Low-Income Commuters

by

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ABSTRACT

Cordon pricing strategies attempt to charge motorists for the marginal social costs of driving in heavily congested areas, lure them out of their vehicles and into other modes, and thereby reduce vehicle miles traveled and congestion-related externalities. These strategies are gaining policy-makers' attention worldwide. The benefits and costs of such strategies can potentially lead to a disproportionate and inequitable burden on lower income commuters, particularly those commuters with poor accessibility to alternative modes of transportation. Strategies designed to mitigate the impacts of cordon pricing for disadvantaged travelers, such as discount and exemptions, can reduce the effectiveness of the pricing strategy. Transit improvements using pricing fee revenues are another mitigation strategy, but can be wasteful and inefficient if not properly targeted toward those most disadvantaged and in need. This research examines these considerations and explores the implications for transportation planners working to balance goals of system effectiveness, efficiency, and equity. First, a theoretical conceptual model for analyzing the justice implications of cordon pricing is presented. Next, the Mobility Access and Pricing Study, a cordon pricing strategy examined by the San Francisco County Transportation Authority is analyzed utilizing a neighborhood-level accessibility-based approach. The fee-payment impacts for low-income transportation-disadvantaged commuters within the San Francisco Bay area are examined, utilizing Geographic Information Systems coupled with data from the Longitudinal Employment and Household Dynamics program of the US Census Bureau. This research questions whether the recommended blanket 50% discount for low-income travelers would unnecessarily reduce the overall efficiency and effectiveness of the cordon pricing system. It is proposed that reinvestment of revenue in transportation-improvement projects targeted at those most disproportionately impacted by tolling fees, low-income automobile-dependent peak-period commuters in areas with poor access to alternative modes, would be a more suitable mitigation strategy. This would not only help maintain the efficiency and effectiveness of the cordon pricing system, but would better address income, modal and spatial equity issues. The results of this study demonstrate how the spatial distribution of the toll-payment impacts may burden low-income residents in quite different ways, thereby warranting the inclusion of such analysis in transportation planning and practice.

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Chapter 1

INTRODUCTION

Overview and Research Question

Cities around the world, in developed and developing countries, face the growing dilemma of how to manage the automobile. In addition to the direct financial costs of building and maintaining infrastructure to handle the increasing demand for private vehicle travel and parking, the negative environmental externalities associated with driving create additional costs that are indirectly paid for by society at large. Because vehicle drivers do not directly pay for these external costs they produce, driving an automobile is significantly underpriced in most places, and therefore rates of driving are inefficiently high. Litman (1997) determines that external costs account for about one-third of total costs per passenger mile for an average automobile. As such, the actual costs incurred by a driver are inefficiently low and reduce the incentive for drivers to switch to other modes of transportation.

In order to address the issues associated with growing vehicular demand in cities, various strategies exist. As Giulliano and Hanson (2004) note, there is no single "magic bullet" that will solve all transportation problems in cities, and a mix of policies that compliment and reinforce one another is therefore needed. Among these potential approaches include the use of *incentives* to encourage drivers to utilize other modes, as well as *disincentives* to reduce demand for driving. These proverbial carrots-and-sticks come in different forms. On the incentive side, public transit improvements, and bicycle and pedestrian enhancements are among those strategies for increasing the attractiveness of alternative modes. Giulliano and Hanson (2004) argue, however, that investing money in alternative modes alone is wasteful public policy when nothing is done to correct the underpricing of private vehicles. Here is where pricing strategies can be used as disincentives that complement and reinforce incentive-based approaches.

Marginal-cost pricing strategies attempt to charge drivers for the full marginal costs associated with driving. First-best pricing approaches that charge drivers on all routes, reflect real-time congestion levels, and accurately internalize all marginal social costs imposed currently are technologically and politically too difficult and costly to implement (Ecola & Light, 2009). Second-best strategies have been proposed as a feasible alternative, including time-based and distance-based pricing, cordon pricing, area pricing, high-occupancy toll (HOT) lanes, and variable pricing on tolled facilities. Though these strategies may have various co-benefits, such as air quality improvements, greenhouse gas (GHG) emissions reductions, or reductions in traffic-related accidents, the direct benefit of congestion relief is perhaps the most easily recognizable goal of pricing strategies. As a result, these policies are typically referred to as "congestion pricing" strategies. Regardless of the terminology applied, Taylor and Norton (2009) argue that the newfound openness of public officials to the idea of pricing is motivated in large part by the potential for revenue generation, particularly in light of declining revenue from motor fuel taxes and other sources, rather than concerns over improving transportation system efficiency or effectiveness. Pricing strategies can therefore involve a variety of goals and objectives, and come in various forms, while concerns over privacy and equity are often voiced as objections against such proposals.

Generally speaking, Prozzi et al. (2006) note that congestion pricing equity concerns often center around the disproportionate impacts for low-income commuters who may be forced to delay their travel departure times or shift to congested roads or less attractive modes for toll avoidance, who may have no transit alternative available and are therefore forced to pay the toll, or who may be forced to forego discretionary trips entirely. The equity implications of pricing strategies, however, can vary greatly depending on the type of strategy and the particular context. Ecola and Light's (2009) review of economics and transportation planning literature notes the difficulty of formulating general conclusions about the equity implications of congestion pricing strategies. They also point out that differences in context make it "essentially impossible" to make direct comparisons between case studies due to various factors impacting the outcome (Ecola & Light, 2009, p. 11). Santos and Rojey (2004) reach similar conclusions when they refute the idea that road pricing is always regressive. In their study of potential cordon-toll strategies in three English towns they find that the impacts can be regressive, progressive, or neutral depending on the specific context of where people live and work and the mode used for commuting. These findings highlight the importance of considering the spatial implications of congestion pricing when analyzing equity.

Among studies of the welfare-based equity impacts of congestion pricing, Ecola and Light (2009) identified three primary groups of research based on the costs and benefits examined. Basic studies examine the impacts of the incidence of the toll payment itself. Other studies also examine the impacts on travel conditions and traveler behavior including the benefits of reduced congestion and travel time, as well as the costs associated with rescheduled, rerouted, or forgone trips. Finally, more elaborate studies consider the implications of toll revenue redistribution on overall equity.

The equity implications of actual fee payment have been examined by various researchers, and in their review of literature Ecola and Light (2009) conclude that generally welfare-based studies have found pricing to be slightly regressive from this perspective. The impact of congestion pricing on low-income commuters may not be so straightforward, however, and is dependent on car ownership and transit use. Low income transit riders prior to congestion pricing may suffer no direct burdens from toll payment following implementation, as many tolling systems exempt transit vehicles and passengers from such tolls. In addition, the spatial distribution of low-income commuters in relation to the toll facility can have significant implications, particularly for those without access to transit alternatives who must rely on a vehicle. As Levinson (2009) notes, boundary effects of cordon pricing schemes are important considerations since the cost of driving to locations within the tolling area can be significantly higher than just outside the boundary. In addition, Bonsall and Kelly's (2005) simulated study of cordon pricing in Leeds concludes that the social exclusion of low-income drivers with no viable alternative to the car would be most pronounced compared to other groups. These studies highlight the important spatial and modal considerations necessary when assessing fee payment impacts of congestion pricing strategies.

Though congestion pricing has been implemented in only a limited number of locations within the US, various strategies are being considered in cities around the country, further highlighting the importance of analyzing the equity implications of such policies. One congestion pricing strategy is currently being examined for the San Francisco area. Known as the Mobility, Access, and Pricing Study (MAPS), this study by the San Francisco County Transportation Authority (SFCTA) examines the feasibility of using congestion pricing in specific areas or routes in the downtown San Francisco area. Two cordon pricing scenarios were approved for additional study in December of 2010 by the Transportation Authority Board (Figure 1).

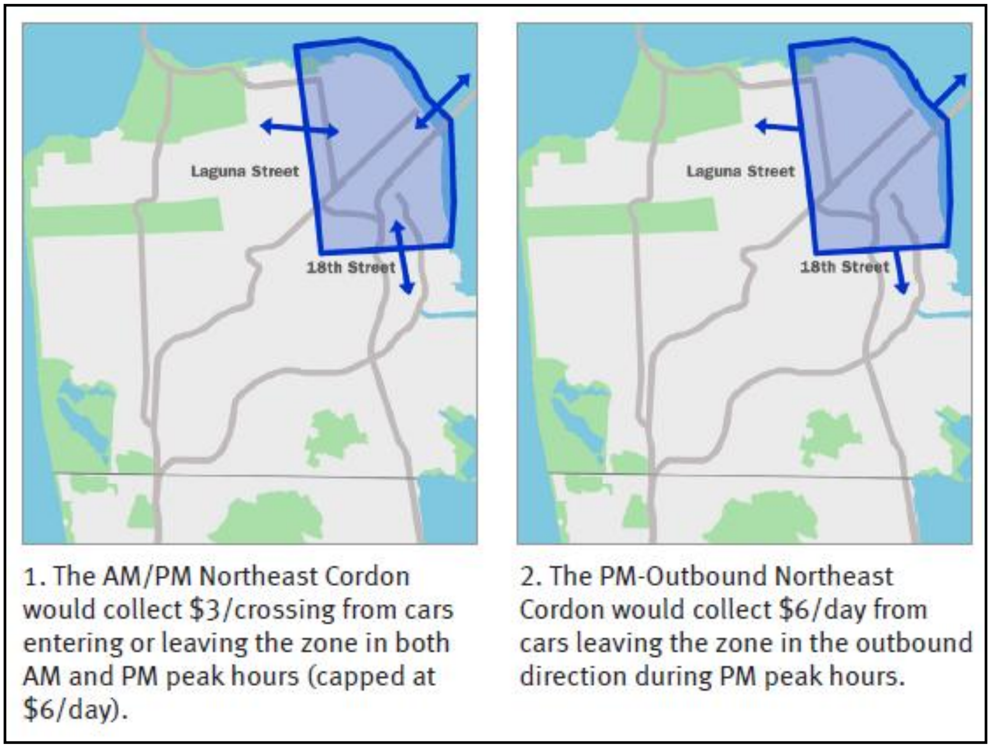

Figure 1. Approved Mobility, Access and Pricing Study Scenarios (SFCTA, 2010).

The MAPS study also recommends a 50 percent discount for low income travelers in order to address equity concerns. At the same time, program revenue would be reinvested in transportation improvements for those traveling to and from the cordon area. The direct impacts of the cordon toll on low-income commuters will depend greatly on their home and work locations, as well as the availability of alternative modes of transportation.

This research explores these implications of congestion pricing strategies by addressing the following research question:

How can transportation planners address the income, modal and spatial equity issues associated with cordon pricing and mitigatedisproportionate fee-payment impacts for disadvantaged commuters, while maintaining the overall efficiency and effectiveness of the cordon system?

It is suggested that the blanket 50 percent discount for travelers with household income under $25,000, as is currently recommended in the MAPS initiative (SFCTA, 2010), might unnecessarily reduce the overall efficiency and effectiveness of the cordon pricing system in order to achieve equity goals. Reinvestment of revenue in access-enhancing transportation-improvement projects targeted at the neighborhoods home to those most disproportionately impacted by tolling fees—low-income automobile-dependent peak-period commuters in areas with poor access to alternative modes—would not only help maintain the effectiveness and efficiency of the system, but would better address spatial-based horizontal equity issues, as well as income-based and modal-based vertical equity issues.

Research Justification and Contribution

The findings of Santos and Rojey (2004) highlight the importance of considering the spatial implications of congestion pricing when analyzing equity, due to the highly contextual nature of where people live and work and the modes they use to travel. In addition, a report by the Federal Highway Administration (FHWA, 2010) that examines current methods for analyzing the environmental impacts of congestion pricing, noted the need for more standardized approaches for examining environmental justice issues. The report noted a particular need for the examination of issues related to geographic location and horizontal equity, including access to transit, access to private vehicles, and residential and work location. The report concludes that these considerations "play as much or more of a role than vertical equity considerations…in explaining differential impacts among various types of people." (FHWA, 2010, p. 3-17)

Ecola and Light (2009) reach similar conclusions in their review of literature on equity and congestion pricing. Among the main findings of their review, they note that even though low-income groups may benefit as a whole from congestion pricing, those with no choice but to drive in congested areas will still be worse off. They also conclude that the distribution of residents and job opportunities will have large equity impacts, while discounts and exemptions used to mitigate such impacts may hurt the effectiveness of congestion pricing by reducing the incentives that discourage driving. In addition they note that most researchers have found that low-income drivers have limited flexibility in their travel behavior and the financial hardship of fee payment exceeds the value of any travel-time savings resulting from congestion pricing.

All of these findings point to the importance of analyzing spatial and modal considerations of equity in cordon pricing, in addition to income-related concerns. As a result, traditional transportation equity studies conducted at a regional scale and focusing on the comparison of burdens and benefits across different income groups may fail to account for the important considerations of where people live and work and the modes they have available to them. This dissertation addresses these concerns and contributes to academic research by focusing on commuting patterns at a neighborhood level and by considering the accessibility of alternative mode choices available. Through spatial analysis of a case study example, it demonstrates the disproportionate impacts of cordon pricing on low-income automobile-dependent peak-period commuters in areas with poor accessibility to alternative modes. In addition, it presents a conceptualization of cordon pricing mitigation through a distribute justice framework, thereby providing theoretical justification for mitigation strategies used to address equity concerns. The results highlight the importance of considering spatial, modal, and income-equity when analyzing pricing strategies and proposed methods for mitigating disproportionate impacts. The research demonstrates that only through a community-level analysis can the distribution of those most disadvantaged be identified, allowing for spatially-informed reinvestment of revenue in access-enhancing projects in these areas, and thereby helping to address equity concerns while maintaining the effectiveness and efficiency of the cordon system. This dissertation contributes not only to an understudied area in academic literature on equity issues in congestion pricing, but also provides a framework that can be applied in practice as transportation planners balance equity, effectiveness, and efficiency concerns.

The findings of this research demonstrate the importance of including community-level equity analysis in transportation planning practice. Once these communities of concern have been identified, community impact assessments (CIAs) can be utilized to determine context-appropriate mitigation strategies to enhance accessibility. It must be stressed that the intention of this research is not to provide any specific policy recommendations *per se*, but rather to provide a new conceptualization of equity issues in congestion pricing and mitigation strategies, and then to apply this conceptualization through spatial analysis of the San Francisco case study and identification of potentially disadvantaged commuters. The top-level findings of the San Francisco analysis illustrate the importance of considering such a framework. Any attempt to make general policy recommendations would run contrary to the primary findings of this research, which demonstrate the importance of community-level equity analysis.

Organization

This dissertation is organized into six sections. In Chapter 2, the concept of congestion pricing is elaborated, including a discussion of the various types of costs and benefits that can accrue to users of the transport system, to public agencies, and to society. The disproportionate impacts of pricing and potential strategies for mitigating them are then presented. This is followed by a more focused examination of cordon pricing strategies in particular, including a discussion of the main objections leveled against such proposals, as well as the types of mitigation strategies that have been employed or considered in planning practice.

Chapter 3 discusses the concept of equity in transportation planning and analyzes such concerns from a distributive justice perspective. This chapter begins with a discussion of justice theory, and analyzes how each justice theorist from different schools of thought would perceive the concept of equity in transportation planning. Prevalent distributive-based theories of justice are discussed, in addition to recently emerging theories of justice, including those that extend beyond distributive concerns. A conceptualization of "equity" is then presented within the differing distributive justice frameworks, in addition to a brief discussion of legislative, executive, and judicial attention to transportation equity concerns in the United States. The chapter concludes by tying these notions of distribute justice and equity together into a theoretical justice framework for analyzing congestion pricing mitigation strategies. This framework is then applied to the cordon pricing mitigation strategy of blanket discounts for low-income drivers, as compared to reinvestment of revenue in transportation-improvement projects targeted at those most disproportionately impacted.

Chapter 4 presents the San Francisco case study that serves as the basis for this research. Here MAPS is examined, including the anticipated costs and benefits that would accrue from the implementation of such a proposal, as well as the mitigation strategies that have been analyzed and recommended under this study. The chapter concludes with a critical analysis of proposed mitigation in the San Francisco case, based on the justice framework presented in the previous chapter.

Chapter 5 elaborates on the methodology employed in this research to examine the San Francisco case study, and discusses how such an approach can assist planners in analyzing equity impacts and determining the location of neighborhoods where community impact assessments (CIAs) can inform decision-making on appropriate mitigation strategies. A method for determining commute patterns of workers impacted by cordon toll payment is discussed, in addition to the potential strengths and limitations of such an approach. Next, a method for analyzing the accessibility of such workers to alternative modes of transportation is presented. Finally, questions regarding the willingness of commuters to walk to alternative modes are addressed, as well as considerations regarding the appropriate unit of areal representation and population assignment.

Chapter 6 discusses the results of the data analysis from the San Francisco case study, highlighting the spatial distribution of those disadvantaged commuters potentially impacted by the proposed cordon system, as well as the availability of transportation alternatives to these effected Bay Area residents. Sensitivity analysis that examines the impact of areal representation units, assumptions regarding willingness-to-walk distances, and Euclidean-based versus network-based accessibility approaches is discussed. Finally, based on the results of the analysis, potential communities of concern with large concentrations of disadvantaged San Francisco-bound commuters are identified in the Bay Area.

Chapter 7 recommends that the communities of concern identified in this research serve as potential study sites for future analysis in the form of a CIA to determine the type of mitigation strategy appropriate based on the context of the immediate area. The chapter concludes with a discussion of the importance of considering income, modal, and spatial equity concerns of congestion pricing mitigation, as conceptualized through a distribute justice framework, and how spatially-informed reinvestment of revenue in transportation-improvement projects targeted at those most disproportionately impacted by tolling fees can help address equity concerns while maintaining the effectiveness and efficiency of the system.

Chapter 2

CONGESTION PRICING IMPACTS AND MITIGATION

In a world of perfect information, theoretical economic efficiency could be maximized by applying "first-best" pricing strategies in transportation that would charge drivers the full marginal costs associated with their driving (Levinson, 2009; Tillema et al., 2012). This would include all externalities that are not paid for by the driver, but rather are paid for by society at large. An example of such an externality is traffic congestion. As a new driver enters a congested roadway, he or she does not pay for the external costs associated with congestion that they impose (the marginal costs of that single driver's decision to travel on the roadway) rather these costs are averaged out across all drivers on the road (e.g. increased travel time) or across society in general (e.g. increased pollution). As such, these types of external costs (imposed on others) have significantly less influence on drivers' decision-making. To correct this problem, a "first-best" pricing strategy applied across all differentiated links of the network and varying dynamically over time to reflect real-time variation in congestion levels can theoretically increase the cost of driving to reflect all associated marginal costs and charge drivers accordingly. Such a tax would reduce driver demand for traveling on the network at costly times or places, with the impacts dependent on the elasticity of demand for each driver with respect to price. Those drivers with a high elasticity of demand (e.g. travelers with unrestricted schedules) will choose to forgo, delay, or reroute their trip, or utilize an alternative mode. Those with low elasticity of demand (e.g. commuters with tight time restrictions) will choose to pay the additional charge and drive. This type of first-best pricing strategy is a form of Pigouvian tax, first accredited to A.C. Pigou (1920) who in his book *The Economics of Welfare* noted that resources can be allocated most efficiently if prices are set equal to the social marginal costs.

In the realm of transportation planning such first-best pricing strategies face significant challenges from a political and public acceptance standpoint (Levinson, 2009; Ecola & Light, 2009). In addition, in spite of technological advances, Tillema et al. (2012) note the “unsolvable” obstacles that prohibit implementation of such a system. They argue that erroneous “utopian” assumptions of perfect information and ability to charge constantly varying tolls that perfectly account for all external costs are compounded by the cognitive limitations that prohibit travelers from making perfect decisions. Thus, while in theory, first-best pricing would be, perhaps redundantly said, the “best” approach, these limitations in practice mean planners and policy makers must look to apply second-best approaches. The challenge therefore becomes how to make less efficient, by definition, second-best approaches the most effective and efficient they can be.

“Second-best” pricing strategies have received considerable attention in transportation literature and offer a range of potential solutions for transport policy (Levinson, 2009). Though not able to maximize efficiency in the same way that a first-best strategy is theoretically capable of, second-best approaches are still able to internalize many of the marginal costs associated with congestion and thereby impact travelers’ decision-making. Due to the imperfect nature of second-best strategies, however, transportation planners are faced with the dilemma of how best to maximize pricing system efficiency and effectiveness, while balancing consideration of equity.

Efficiency and Effectiveness of Pricing

Defining the efficiency and effectiveness of congesting pricing largely depends on the perspective utilized. As Taylor and Norton (2009) note, the focus of politicians and decision-makers in the United States tends to emphasize the expenditure effects of transportation programs and the revenue-generating potential of such policies. This results in an emphasis on the efficiency and effectiveness of the performance of the finance program itself. Under this viewpoint, the goal of effectiveness emphasizes maximizing the political acceptability of a program and the ability to generate stable and predictable revenue, while the goal of efficiency implies minimizing administrative costs relative to the revenue collected. Taylor and Norton contend, however, that such a focus ignores the impacts of these programs on the performance of the transportation system itself, which they contend is essential for understand potential equity impacts. From a system performance perspective, the goal of effectiveness involves lowering transportation costs (e.g. congestion) and optimizing the utilization of existing capacity, while the goal of efficiency would consider the optimization of transportation service at a given level of expenditure. Planners must therefore consider the effectiveness and efficiency of both the program itself and the impacts of the program on system performance to have a full understanding of the impacts of congestion pricing.

Congestion Pricing in Practice

Many second-best pricing systems are already utilized in cities around the world, while others have considered the implementation of such strategies for dealing with the problems associated with traffic congestion. For example, some European countries with strong forms of centralized planning have embarked on second-best system-wide strategies, such as efforts in the Netherlands in 2007 to develop a nationwide kilometer charge differentiated by time, place, or environmental costs by utilizing onboard GPS receivers (Tillema et al., 2012). In the United States, distance-based charging programs have been examined as a replacement for the gas tax, including a pilot program tested in Oregon (Walker, 2011). Similar initiatives using GPS technology have pushed the idea of pay-as-you-drive insurance (based on miles driven) toward one of pay-*how*-you-drive insurance (based on driver speed/behavior, time of travel, location of travel, etc.). Yet there are significant political hurdles to overcome in such systems, particularly from a privacy and public acceptability standpoint. The Netherlands plan was suspended indefinitely following a change in government in 2010, due in part to the high costs of implementation and low public acceptance (Tillema et al., 2012), while pay-as-you-drive insurance has only recently started to catch on in the US, with a handful of companies offering such contracts for private vehicles, and only one offering pay-how-you-drive contracts for fleet vehicles (Kremslehner & Muermann, 2013). In addition, in the United States no distance-based pricing system has yet to be implemented. Levinson (2009) notes the privacy concerns regarding such strategies, since they typically involve the use of in-vehicle GPS units that allow for intensive tracking of vehicles by time and place.

In addition to network-wide and distance-based strategies, second-best pricing in the transportation sector also includes two additional design categories: facility-based strategies (tolls applied to particular roads, bridges, or tunnels, high-occupancy toll or HOT lanes, and express lanes) and area-based strategies (fees charged for crossing a cordon around a charged zone and area-licensing systems with a fixed daily fee). Area-based strategies have been implemented in different cities worldwide, including Singapore, London, Stockholm, Oslo, and Milan. In the United States, facility-based strategies have received more attention, and have been implemented in various locations. HOT/express lane facilities have been introduced on Route 91 in Orange County, I-15 in San Diego, I-394 in Minneapolis, I-25 in Denver, and I-680 in eastern San Francisco Bay among others, while variable bridge tolling has been applied in Ft. Myers, Florida, and on the San Francisco Bay Bridge. Although no area-based strategies have been implemented in the United States, New York City proposed a congestion pricing system as part of its wider sustainability plan in 2007. With support of the mayor and the city council it was voted for adoption, but was later blocked in the State Assembly and abandoned after failing to meet deadlines for federal funding (Walker, 2011). The San Francisco MAPS study, if approved for implementation, would be the first such area-based strategy in the US.

With the increased attention given to congestion pricing in recent years, the costs and benefits of facility-based and area-based strategies for users, public agencies, and society in general, and the way they impact low-income communities in particular, have been the subject of various research studies. In order for planners to mitigate potentially inequitable impacts of congestion pricing, it is important to have a clear understanding of the types of costs and benefits that my accrue, as well as the way they are distributed across different individuals, groups, and geographic areas. The following sections examine the different types of costs and benefits that can result from congestion pricing strategies.

Congestion Pricing User Costs

The first types of costs related to the use of pricing strategies are those incurred by actual users of the system. Perhaps the most obvious user cost of any pricing strategy is the payment of the fee itself. The equity implications of fee payment have been examined by various researchers, and in their review of literature Ecola and Light (2009) conclude that generally welfare-based studies have found pricing to be slightly regressive from this perspective. The type of pricing strategy can also determine the regressive or progressive nature of the fee. Franklin's (2007) study of potential bridge tolling in the Seattle area concluded that toll payment was the largest factor contributing to regressivity. Cordon pricing and area-wide pricing strategies can have significant impacts on low-income communities depending on the location of the tolling area in relation to the spatial distribution of low-income communities. As Levinson (2009) notes, such boundary considerations of cordon pricing schemes are important to analyze since the cost of driving to locations within the tolling area can be significantly higher than just outside the boundary. Bonsall and Kelly's (2005) simulated study of cordon pricing in Leeds concludes that the social exclusion of low-income drivers with no viable alternative to the car would be most pronounced compared to other groups. Eliasson and Mattsson (2006) concluded, however, that the Stockholm congestion pricing trial produced negative impacts for all income groups, with high-income groups paying the highest amounts in fees and experiencing the largest net loss, in spite of any travel time improvements and higher value of time. In addition, as Parkany (2005) and Weinstein and Sciara (2006) point out, the form of fee payment can cause additional equity concerns if low-income drivers without credit cards or checking accounts cannot obtain transponders or cannot afford required deposits or toll prepayments. Beyond these direct fee payment considerations, Forkenbrock (2006) and others have argued that pricing strategies on selected arterials and highways are a form of double taxation because the infrastructure may have already been financed through motor fuel taxes or other forms of taxation. As Ecola & Light (2009) point out, however, the external social costs of pollution and congestion are not paid for by drivers through such taxation mechanisms, and can be accounted for through pricing strategies.

Penalty payments are another potential user cost that extends beyond normal fee payment. Though Evans (2007) makes estimates of such impacts for users as part of overall compliance costs for London's congestion pricing, no research was identified that explored any potential equity impacts associated with these costs.

Cost of modal shift and foregone, rescheduled, or rerouted trips may impact users of previously un-priced infrastructure that are converted to priced-facilities. Generally speaking, Prozzi et al. (2006) note that road tolling equity concerns often center around the disproportionate impacts for low-income commuters who may be forced to shift to congested roads or less attractive modes for toll avoidance, who may have no transit alternative available, and who may be forced to forego discretionary trips entirely. Richardson and Bae (1998), assuming homogeneity of users, find that congestion pricing negatively impacts all users due to the additional fee paid as well as longer travel times for those deviated onto other routes. For heterogeneous travelers with differing values of time, however, they argue that those with higher values (and typically higher income) benefit due to decreased travel time on the tolled facility. The inability to change modes or alter trip plans may be another confounding equity factor for low-income drivers. Ecola and Light (2009) conclude that most research has identified low-income drivers as negatively impacted by congestion pricing due to their limited travel flexibility and lower value of travel-time savings. This is highlighted by Schweitzer and Taylor (2007), who note that some low-income drivers who must use priced facilities during peak hours due to limited flexibility may be worse off, and by Cain and Jones (2008), who find similar results for low-income drivers without alternatives in Edinburgh.

Induced demand from congestion reduction is another potential by-product of pricing strategies. Eliasson et al. (2009) note that travel surveys conducted during the Stockholm cordon pricing trial period confirmed an increased in travel demand as a result of inner-city congestion reduction. The costs incurred due to induced demand should therefore be balanced against traffic reductions attributable to congestion pricing implementation.

Congestion Pricing User Benefits

Among the benefits that accrue to the users of priced facilities, reduced travel time and congestion are among the most widely mentioned in studies reviewed. Eliasson et al. (2009) note that traffic in the charged zone of Stockholm's pricing cordon was reduced by 22 percent compared to a year earlier. This finding highlights the potential for pricing strategies to impact travel times, however the equity implications of these benefits may vary. As Small (1992) notes, previous drivers on a newly tolled highway who have a high value of time will benefit most from congestion pricing due to improved travel times that offset the cost of fees. Small and Yan (2001) conclude, however, that value of time differs between travelers and this heterogeneity is important to include in evaluations of such pricing strategies. In addition, Small, Winston, & Yan (2005) find that value of time can vary not only due to the heterogeneity of drivers, but also due to heterogeneity of trips. Certain drivers that may have a lower value of time overall due to lower income, may have a higher value for certain trips that are of high priority or importance, such as journey-to-work trips. Small (1992) also notes that bus users and carpoolers exempt from tolls would benefit even more, as they would enjoy travel time reductions at no extra costs. Evans (2007) notes that bus passengers in the London area-pricing zone received overall net benefits due to time and reliability savings. Small's (1983) examination of congestion pricing scenarios for the San Francisco Bay Bridge, however, found overall negative impacts for low- and medium-income groups in all cases based on travel time reduction. In their analysis of cordon pricing in Stockholm Eliasson and Mattsson (2006) emphasize fee impacts and revenue use as much more important considerations than value of time for determining the equity of such strategies. Evans (2007) concludes, however, that travel time savings were the dominant benefits resulting from congestion pricing in London, far outweighing other quantified benefits. Meanwhile, Levinson (2009) highlights a confounding factor for studies attempting to examine the benefits of travel time reductions through the valuation of time, noting that the marginal utility of money for those of lower income may be higher than higher-income groups. This makes comparison of time values between income groups more difficult than apparent on the surface.

Improved reliability is another benefit that can accrue to system users. Reliability savings can also accrue to transit riders on priced facilities. For example Evans (2007) noted that reliability coupled with time savings as a result of congestion charging produced benefits for transit users in London.

Reduced fuel and vehicle operating expenditures are another potential benefit for users of priced facilities. Though such reductions may accrue to users of the system, Evans (2007) found that in the case of London's congestion pricing these benefits coupled with time and reliability did not exceed the charge payments and additional compliance costs incurred by users. Though such studies mention the overall impacts of fuel and vehicle operating expenditure reductions, the equity implications of these user benefits are not addressed in the literature reviewed.

Reduced vehicle accidents costs are a potential benefit for users as well. In London, reported personal accidents dropped by 10 percent following the introduction of congestion charging (Evans, 2007). Boundary effects can complicate such benefits for areas nearby tolled facilities or cordons. Drivers attempting to avoid tolls through trip rerouting may redistribute traffic and congestion to nearby areas and increase vehicle accidents on these routes. These potential impacts of boundary effects on accident rates, however, were not addressed in literature reviewed. In addition, Ecola and Light (2009) note the lack of research addressing the equity implications of vehicle accident rate changes resulting from pricing strategies.

Congestion Pricing Social Benefits

In addition to those benefits accrued by actual users of a priced system, society as a whole may also receive certain benefits from these strategies. One potential social benefit of congestion pricing strategies is the reduction of greenhouse gas (GHG) emissions. Cordon and area-wide pricing strategies may reduce VMT (and hence GHG emissions) as drivers forego trips or shift to other modes. According to Evans (2007), average carbon dioxide emission rates fell as a result of reductions in fuel consumption after implementation of area-pricing in London. A National Research Council (NRC, 2009) report notes, however, that congestion pricing may simply shift travel to less congested times or places and actually have little impact on trip reduction and GHG emissions.

Improvements in air quality are another potential social benefit of transportation pricing strategies. While reductions in gasoline consumption as a result of pricing strategies may directly impact GHG emissions, Levinson (2009) notes that reduction of gasoline consumption does not correlate directly with air pollution or the potential health damages that can result. As Ecola and Light (2009) point out, measuring the air pollution impacts of pricing strategies is technically difficult due to weather and climate conditions, while these impacts are difficult to translate directly into social health and quality of life benefits due to questions of exposure and causality. Evans (2007) determined air quality improvements in the London charging zone for nitrogen oxides and particulate matter, however the benefits were estimated to be small compared to travel-time benefits. Tonne et al. (2008) note, however, that socioeconomically deprived areas of London with the highest air pollution concentrations benefited from greater emissions reductions compared with other areas, though these benefits were rather small in magnitude. Mitchell (2005) also concluded that cordon pricing in Leeds would reduce air pollution to the benefit of low-income residents. Boriboonsomsin and Barth (2007) highlight the way in which air quality impacts depend on the specific context and design of the system.

Reduction of noise pollution is another potential social benefit of pricing strategies. Ecola and Light (2009), however, found no studies that examined the equity impacts of noise pollution changes resulting from pricing strategies. Evans (2007) does address the possible benefit of noise reduction, but found no measurable difference in ambient noise levels attributable to London's congestion pricing. Noise impacts from pricing strategies are further complicated by the trade-off between noise and traffic speeds. As Bae (2004) notes, when traffic congestion increases, resulting noise in impacted neighborhoods actually declines. Pricing strategies that improve traffic flow may actually increase noise pollution as a result. The equity implications of this appear lacking in the literature on such strategies.

Congestion Pricing Public Agency Costs

In addition to user and societal benefits and costs, public agency costs must also be accounted for when analyzing pricing strategies. The cost of necessary infrastructure, implementation, and operation of priced facilities can be significant, though revenue generated from pricing is assumed to cover the repayment of these costs. In addition to these direct expenses, however, other public agency costs should also be recognized. Loss of fuel tax revenue due to reduced VMT is a potential cost that must also be accounted for, particularly if pricing strategies are designed primarily as revenue-producers. In addition to fuel taxes, other revenue generating sources may be negatively impacted by pricing strategies. In London for example, Evans (2007) noted a reduction of 18 percent in on-street parking revenues within the charging zone between 2002 and 2003. Finally, the costs of complimentary transit infrastructure to accommodate modal shift is a consideration necessary for cordon and area pricing strategies as well. Eliasson et al. (2009) noted that the city of Stockholm increased public transport services by 7 percent and increased park-and-ride facility capacity by 29 percent in anticipation of the implementation of congestion charging.

Recognizing the public agency costs for pricing strategies provides a clearer picture of all associated expenses that may be necessary; however, significant benefits may accrue to certain groups if pricing strategies are used as a substitute for other forms of revenue generation and infrastructure investment funding. Schweitzer and Taylor (2008), for example, concluded that low-income communities fared much better than middle-income communities under a toll scheme as opposed to reliance on sale tax revenues for bond repayment.

Conclusions on Pricing Strategy Costs and Benefits

The distribution of costs and benefits from pricing strategies can vary greatly depending on the type of strategy and the particular context. Santos and Rojey (2004) find that the impacts of pricing depending on the specific context of where people live and work, and the mode used for commuting. Ecola and Light (2009) reached a similar conclusion, and point out that the heavy dependence on computer modeling and the difficulty with monetizing the various costs and benefits of pricing strategies (such as the value of time, foregone trips, accidents, and pollution) confounds the issue, while differences in context make it "essentially impossible" to make direct comparisons between case studies (Ecola & Light, 2009, p. 11).

Within the highly contextual nature of pricing strategy cost and benefit distribution, different methods exist for mitigating disproportionate impacts on the disadvantaged. The following section examines some of the most widely recognized forms of mitigation available for transportation planners to incorporate into pricing strategies.

Mitigating Disproportionate Pricing Impacts

Various methods for mitigating the disproportionate impacts of pricing strategies on vulnerable low-income and minority communities have been proposed and implemented in cities around the world. Much of the literature reviewed on pricing mentions revenue redistribution as the most important mitigation strategy for addressing equity (Small 1992; Eliasson & Mattsson 2006), and as Santos and Rojey (2004) recognize, the most important determinant for public acceptance of pricing is the way in which revenue is used. Other forms of mitigation, however, have also been analyzed. In some cases, these alternative mitigation strategies have the potential to significantly influence the distributional impacts of pricing burdens. Of those strategies, discounts and exemptions have been utilized in many implemented pricing programs. The design of pricing systems have also been altered in some cases to account for the spatial distribution of vulnerable communities, while traffic calming has been added to assist with mitigating localized impacts. Pre-pricing transit improvements and the utilization of alternative fee payments methods have also been proposed, and in some cases enacted, in order to further lessen the burden placed on disadvantaged groups. The following section reviews these mitigation strategies.

Revenue Distribution

One mitigation strategy often mentioned in the literature on congestion pricing relates to the use of pricing revenue. Revenue from pricing strategies, however, can be distributed in various ways with differing equity impacts depending on the local context. Eliasson and Mattsson (2006) note the significance of careful monitoring of revenue use, beyond mere examination of the toll charge itself. They examine lump-sum redistribution, improvements for public transport, driver refunds, and income tax refunds for Stockholm, and determine that lump-sum and transit investments are both progressive strategies. Arnott, de Palma, and Lindsey (1994) examine the impacts of toll revenue distribution in three ways: no rebate, equal lump sum rebates to drivers, and roadway capacity expansion. They determine that tolls without rebates tend to hurt the poor and benefit the rich, lump sum rebates are progressive and provide the poor with a greater proportional income increase, while capacity expansion benefits those travelers with higher absolute travel costs.

Santos and Rojey (2004) note how the use of revenues from road pricing is a crucial factor that can influence public opinion regarding the acceptability of such programs. In their study of a proposed road pricing scheme in Leeds, they find that revenue investments made in public transit, traffic calming, and pedestrian/bicycle facilities would result in a progressive pricing program. They note that this is due to relatively low household car ownership, with only 59 percent of households having access to a vehicle (p.5). Transit service therefore remains the only option available for many. Bonsall and Kelly (2005) echo the importance of revenue investments in transit and other alternative modes in their examination of Leeds, and note that such strategies can potentially offset the negative effects of pricing on the socially excluded. They note that not only transit improvements, but also other alternatives such as car sharing and community-based transport services can also be an effective use of revenue for mitigating disproportionate impacts.

Discounts, Exemptions, and Credits

The incidence of a toll increase that is designed to account for the marginal costs of roadway use can have significant impacts for a person on a fixed income. The actual amount of the toll increase is therefore a decision that has important equity implications. One potential way to mitigate such impacts and reduce the burden of pricing on low-income drivers would be to set tolls lower than the marginal social costs incurred. As Schweitzer and Taylor (2008) note, however, an alternative strategy would be to provide programs targeted at easing the burden of pricing for these individuals. Providing low-income drivers with discounts or full fare exemptions for disadvantaged travelers is one such strategy. As Wachs (2005) concludes, equity concerns must be seriously addressed if pricing is to make progress in the US and overcome political hurdles, therefore additional experimentation with “lifeline” rates for low-income drivers will likely to be included in future road pricing strategies.

Though Duff (2004) acknowledges that the regressive impacts of a user fee can be prevented by exemptions for low-income households, the author also cautions that exemptions and rate variations for these intended purposes are likely to produce rates that further deviate from economic efficiency. Bonsall and Kelly (2005) also note in their review of proposed cordon pricing that exemptions, though easy to provide, limit the profitability of such programs and may not be the most effective way for mitigating impacts on low-income residents. Indeed the use of discounts and exemptions with any pricing program can reduce the revenue collection potential, in addition to potentially undermining congestion-reduction and other environmental goals. For example, exemptions to the Stockholm cordon pricing program, which provide free access to drivers of taxis, buses, alternative-fuel vehicles, and by-pass traffic, accounted for 30 percent of all vehicles passing through the cordon zone (Eliasson et. al 2009). Impacts of exemptions in the London area-pricing scheme are even more pronounced. According to Evans (2007), analysis of traffic within the charging zone indicated that only 40 percent of vehicle movement is made by those paying the full congestion charge. Of the remaining vehicles, 4 percent were residents (receiving a 90 percent reduced rate); 7 percent were buses, 23 percent were taxis, 10 percent were licensed private-hire vehicles, and 2 percent were emergency service vehicles (all exempt from free payment); 5 percent were blue badge holders (providing exemptions for travelers with severe mobility problems); 4 percent faced penalty charges for nonpayment, and the remaining 5 percent received other discounts or exemptions. Though these numerous exemptions may appear to have significant impacts on revenue generation and congestion reduction potential, according to Ison and Rye (2005) the wide range of exemptions provided in the London program appears to have made the introduction of congestion pricing more palatable for Londoners facing the newly enacted charges.

Indeed the influence of discounts and exemptions on the political acceptance of pricing appears to be an important factor, though the results can swing in both directions. For example, the failed Hong Kong electronic road pricing (ERP) pilot program provided full exemption to taxis, in part due to well-organized political pressure exerted by these interest groups for exemption from pricing. Private vehicle drivers, however, felt discriminated against because taxis were exempt yet create considerably more congestion (Hau, 1990). Exemptions and lifeline pricing for HOT lanes programs can also result in public backlash in some instances. Public opinion research conducted by Parsons Brinkerhoff (2005) concluded that average (middle-income) residents perceive HOT lanes discounts for low-income drivers as inequitable and such special exemptions and programs received virtually no support among this group. Whatever the situation or the form of pricing utilized, Rajé (2003) stresses the importance of ensuring that the provision of exemptions are founded on considerations of equity.

The concept of pricing programs based on a system of credits is also gaining increased attention, though no such systems have been implemented as of yet. Kockelman and Kalmanje (2005) proposed a form of credit-based congestion pricing in which tolls generated from the system would be uniformly returned to all registered drivers, allowing peak period drivers who travel more miles to subsidize others by buying their allowance credits. DeCorla-Souza (2005) extended his concept of FAIR lanes, in which users of regular un-priced congested lanes received credits as compensation for not utilizing uncongested priced lanes, and applies this concept to a network-wide approach. FAST

Miles (DeCorla-Souza, 2006), another credit-based proposal, would allocate a certain number of free credits for use of highways during peak periods, while additional miles would be available for purchase at rates based on congestion levels. Though none of these proposals have been actually implemented, they demonstrate the increasing interest in examining alternative mitigation strategies and the potential for basing these on a credit allowance system.

System Alignment Changes

The spatial impacts of pricing can be pronounced, as highlighted by the issue of boundary effects. As Levinson (2009) points out, such boundary effects of cordon pricing arise as the cost of driving to destinations just inside the cordon significantly exceed the costs of staying just outside the boundary. Rajé (2003) also highlights the potential development of such boundary problems in road user charging programs. Bonsall and Kelly (2005) case study of Leeds demonstrates that the impacts of cordon pricing on at-risk groups is dependent on the extent and alignment of the cordon, in addition to the way charge are determined. Fridstrom et al. (2000) also note the spatial impacts of road pricing cordons and the size of the charge zone, determining that a small cordon burdens those residents inside the cordon, while a large cordon impacts such drivers (who can make trips within the zone for free) less than drivers from outside the zone. For cordon pricing, therefore, the specific alignment of the boundary can have significant equity implications. Alterations to cordon boundaries may therefore be an effective way of addressing spatial equity issues.

Traffic Calming

In addition to the impacts of actual fee payment, other researchers (Langmyhr, 1997; Rajé, 2003) have noted the importance of considering other boundary effects that may also result from pricing strategy implementation, such as increased traffic or parking demand in areas adjacent to priced facilities. Congestion pricing on tolled facilities, cordon pricing and area-pricing, however, may present serious boundary effects and researchers have identified these issues as potentially significant for such pricing systems. Levinson (2009) notes that spillover parking issues can result from cordon or area-pricing programs, with drivers attempting to avoid the toll by parking just outside the charged zone. The author notes that these boundary effects can be particularly significant if parking in impacted boundary neighborhoods is uncharged or undercharged. Rajé's (2003) qualitative focus group research of public response to road pricing in Bristol found a key concern of a cordon pricing proposal was the potential for boundary problems and spillover parking in a primarily ethnic minority neighborhood at the edge of the cordon. To mitigate such spillover effects, parking restrictions and residential parking zone designations, enhanced parking enforcement, park-and-ride facilities outside the impacted area, and car-sharing incentives can be implemented in tandem with pricing.

Another boundary effect that may arise from pricing is increased vehicle traffic in areas just outside the charge zone, as drivers attempt to by-pass the area and avoid the toll. Indeed Safirova et al. (2006) note that cordon pricing has long been criticized for causing increased traffic congestion in areas just outside the cordon zone. This is also emphasized by May and Milne (2000), who point out that congestion charging on select roadways may significantly increase "rat running", as travelers avoid these facilities and utilize minor routes free of charge, thereby increasing traffic in neighboring areas. Santos and Fraser (2006) note that in the case of London's area-pricing scheme, as anticipated, traffic increased on the Inner Ring Road outside the congestion area. In this case, traffic management strategies, such as retiming of traffic signals, were employed prior to pricing implementation in order to prevent increased congested due to diverted traffic. In other situations, rat running can also be mitigated by employing various traffic-calming measures on impacted minor roadways surrounding the cordon zone. These traffic calming strategies can include an array of volume reduction strategies (partial or full street closures, diagonal traffic diverters, etc.) or speed reduction measures.

One final boundary effect of cordon pricing and variable bridge tolling relates to the dynamic nature of the tolling method employed. As Lindsey and Verhoef (2001) note, most variable pricing systems utilize a step tolling structure, in which tolls increase and decrease in jumps as opposed to fine tolling methods that are continuously time-varying. As a result, many priced facilities experience surges of traffic such before an increment occurs as well as after decrements. For example, in Singapore tolls during peak periods change every half hour. Menon and Kian-Keong (2004) note that when the incremental toll increase is steep, motorists will speed up to avoid paying the higher rate. When decrements are significant, motors slow down and even park on the roadside before the entry to the charging gantry in order to avoid the higher toll. Safety issues and other externalities resulting from such behavior can be mitigated through increased enforcement or through the addition of graduated charges during the five-minute spans between tolling increments, as was introduced in the Singapore example.

The consideration of these various types of impacts on communities in close proximity to priced facilities is an important element of a successful pricing program. Smirti et al. (2007) note that according to public opinion research, projects in which the boundary effects on surrounding areas are anticipated and where appropriate mitigation measures have been developed are more likely to generate public acceptance.

Pre-Pricing Implementation of Transit Improvements

Although much of the discussion on the use of pricing revenues tends to focus on the provision of transit improvements, the introduction of transit service additions or extensions prior to the implementation of pricing is seen as another strategy for mitigating the impacts of such programs. As noted by Rajé et al. (2004), the impacts of increased parking demand just outside a cordon zone and accompanied modal shift to transit for the remaining trip may increase crowding of public transport services. Prior to implementation of area-pricing in London, bus service frequency was increased, new routes were added and others altered, and larger buses were added to the fleet in anticipation of increased bus patronage (Santos & Fraser, 2006).

Meanwhile in Stockholm, four months prior to the launching of cordon pricing public transit services were enhanced with the addition of 16 new bus lines, expansion of rail service frequencies, and the opening of park-and-ride lots. According to an onboard survey assessment made by Eliasson et al. (2009), though the transit service expansion alone may have generated only a small increase in public-transport trips as compared to the reduction in overall vehicle traffic over the charge cordon, they conceive that the congestion charge effects were enhanced as modal shift was made easier through these improvements. The authors conclude that if this is the case, part of the congestion pricing effects should be attributed to the interaction with expanded public transport. They point to similar conclusions made by Kottenhoff and Brundell-Freij (2009), who also note that the stand-alone effects of transit expansion on modal split may have been small in the Stockholm case.

A study of Edinburgh's cordon pricing referendum by Gaunt, Rye, and Allen (2007) determined that a contributing factor to its political failure was that planned improvements to the public transport system after the implementation of pricing were considered by many voters as arriving too late, or were "insufficient, irrelevant, or ill-defined" (p. 100.) They conclude that a guaranteed program of specified transit improvements might have improved the outcome of the referendum. These findings are echoed by Bhatt, Higgins, and Berg (2008), who determine that the promised public transport improvements in Edinburgh should have been planned earlier so that voters could have experienced the real benefits of the improvements prior to charging.

Alternative Fee Payment Methods

Another potential equity issue of pricing strategies relates the methods of toll payment available. As Parkany (2005) highlights, low-income drivers may face barriers to obtaining transponders required to access priced facilities. Often such systems require a significant deposit, as well as toll prepayments. Many low-income potential road users do not have access to credit cards or checking accounts, while many cannot readily afford the required deposit for a transponder account. Weinstein and Sciara (2004) note how a driver's ability to acquire a transponder can influence the accessibility of priced facilities. As a mitigation measure in response to these issues, Parkany (2005) suggests that agencies should consider payment method systems similar to those used in Puerto Rico, which allows drivers to buy and replenish cash cards at convenience stores, gas stations, and other retail outlets.

All of these mitigation methods can potentially reduce disproportionate impacts from pricing strategies. As noted, cordon pricing presents unique challenges from a public-acceptance standpoint. The following section highlights some of these issues and mitigation strategies that have been employed or examined for use in proposed cordon pricing systems worldwide.

Case Study: Cordon Pricing

Cordon pricing is a "second-best" pricing strategy. Unlike network-wide strategies, however, cordon pricing is much more limited in its ability to internalize the full external costs associated with driving. Much of these limitations have to do with the highly spatial natural of cordon pricing. Unlike a network-wide strategy that charges all drivers, cordon pricing only charges those drivers who actually cross a specific boundary. As such, cordon pricing does not internalize any of the social costs associated with drivers that do not cross this cordon, but nonetheless contribute to network-wide congestion and the production of other environmental externalities (Figure 2). In addition, travel conducted by vehicle *within* the cordon zone is also not charged, in spite of that fact that it could significantly contribute to congestion levels within that zone. On the other end of the spectrum, drivers who must cross the cordon numerous times each day are faced with a much greater toll burden than those who can bypass the cordon, adjust their travel times, switch to other modes, or forgo their trip altogether. Of course the specific goal of cordon pricing is often just that—to encourage those who regularly drive in congested areas and during congested times to shift their travel patterns. For those with no such alternative option, however, the burdens of cordon pricing will fall heavily on their shoulders.

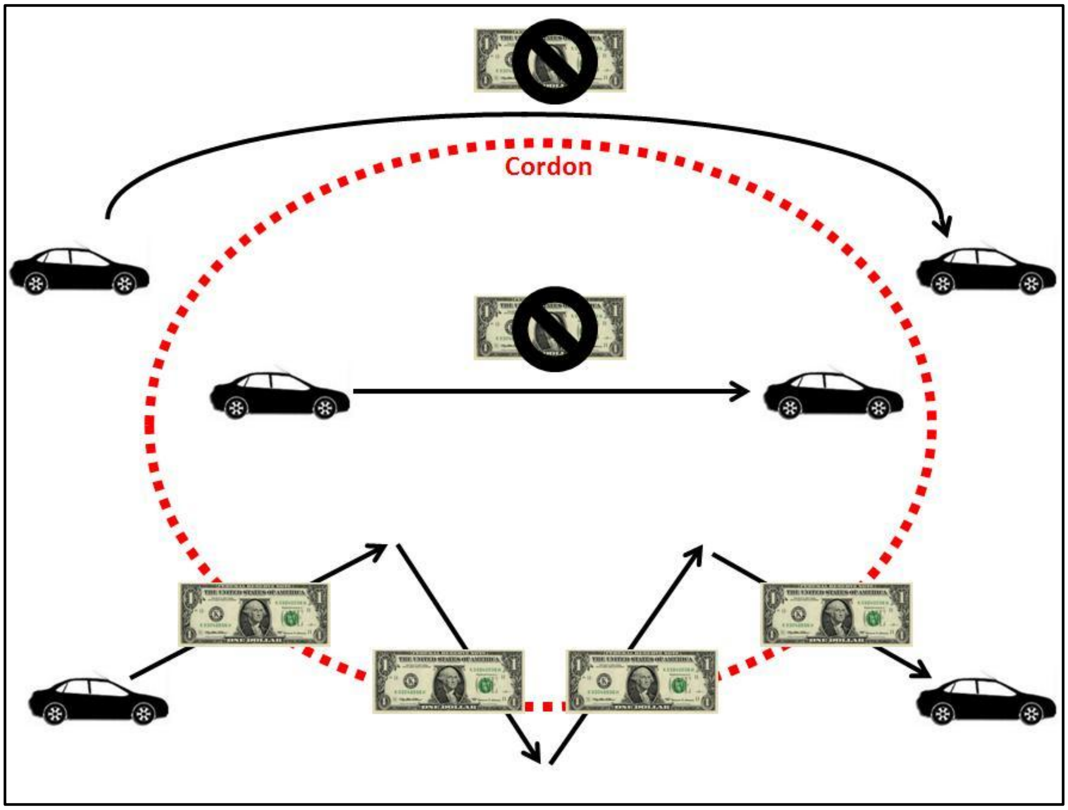

Figure 2. Limitations of cordon pricing.

These spatial considerations of the burden of cordon pricing fee payment are highlighted by equity-based objections that have been lodged against new and proposed cordon pricing systems. In the case of Stockholm, for example, residents on the island of Lidingö (accessible only via the cordon zone) objected to the fact that they would be charged for crossing the cordon, even if their intended destination was outside of the charge zone. To overcome this objection, exemptions were provided to residents on such through-trips (Eliasson et al., 2009). This case illustrates the highly spatial nature of cordon pricing, and the fact that the alignment of the cordon itself will have significant and differing impacts for different individuals based on their particularly location. Concerns over the fact that drivers traveling to and from destinations within the cordon zone could avoid the toll were also voiced in the Stockholm situation, though no adjustments to the system design were made.

One alternative form of pricing that can help to alleviate issues of intra-zone travel and internalize the congestion created by such trips involves the use of area-based pricing (as used in London) instead of a stationary cordon (as used in Stockholm and Norwegian cities). In an area-based system, drivers are not charged each time they drive over the cordon boundary, but rather are charged a flat daily fee for driving anywhere within the charge zone. This system design has the advantage of charging intra-zone travelers for (a portion) of the social costs they impose. It can, however, have a limited effect on reducing a driver's overall amount of daily travel, since the fee is only imposed on a daily basis and is not based on actual mileage driven within the zone area. As such, a person making a single trip in the charge zone would pay the same daily amount as a person making multiple trips through the zone, in spite of the differences in environmental externalities generated by either driver.

Finally, objections to cordon pricing may arise from those drivers who must travel across the cordon multiple times during the course of the day. Taxi drivers are often included in this group, and many proposed and implemented cordon pricing strategies provide discounts or exemption for taxis. Another example of such objections is the Norwegian city of Trondheim, which enacted its one-hour exemption rule following complaints from parents facing multiple cordon charges for dropping off their children within the zone (Ecola & Light, 2009). Such discounts and exemptions, however, do further limit the ability of cordon pricing systems to effectively internalize the social costs of driving.

In addition to the geographic implications of cordon pricing, the burden of fee payment can also produce winners and loser among different income groups and among those with differing levels of mobility. Cordon pricing strategies can be particularly impactful for low-income communities depending on the location of the tolling area in relation to the spatial distribution of low-income communities. Prozzi et al. (2006) note that road tolling equity concerns often center around the disproportionate impacts for low-income commuters who may be forced to shift to congested roads or less attractive modes for toll avoidance, who may have no transit alternative available, and who may be forced to forego discretionary trips entirely. The impacts, however, depend on the accessibility of alternative options for travelers in those locations. If available transit service provides high levels of accessibility for low-income residents in these communities, the impacts of cordon pricing fee payment may be minimal to non-existent, since most proposed and operational cordon pricing systems provide full exemptions for transit vehicles. For low-income drivers who must rely on their vehicle as their primary form of transport due to poor alternative-mode accessibility, however, cordon pricing can create a significant hardship. Bonsall and Kelly's (2005) simulated study of cordon pricing, for example, concluded that the social exclusion of low-income drivers with no viable alternative to the car would be most pronounced compared to other groups.

Some fee-payment impacts of cordon pricing may be partially mitigated through congestion reduction, improved traffic flow, and shortened travel times resulting from cordon pricing itself. As previously noted, however, Richardson and Bae (1998) determine that those with higher values (and typically higher income) benefit most from congestion pricing due to decreased travel time, while Ecola and Light (2009) conclude that most research has identified low-income drivers as negatively impacted by congestion pricing due to their limited travel flexibility and lower value of travel-time savings. Eliasson and Mattsson (2006) conclude, however, that high-income groups in Stockholm paid the highest amounts in fees and experiencing the largest net loss, in spite of any travel time improvements and higher value of time.

Beyond the often-stated goal of congestion reduction, some cordon pricing systems may have other explicit goals that are given higher priority, particularly the generation of much needed revenue. In the Norwegian case, cordon pricing was instituted specifically with the goal of producing revenue to fund (primarily roadway) improvements, rather than the explicit goal of traffic congestion reduction (Ieromonachou, Potter, & Warren, 2006).

In order to mitigate the impacts of fee payment on the disadvantaged, revenue generated from cordon pricing can be utilized in various ways. If pricing revenue is allotted to a general fund for non-transportation uses and no rebates are offered to drivers, this tends to be a regressive strategy for low-income drivers. Revenue can be redistributed back to drivers in lump-sum rebates, which is typically a progressive strategy with regards to income. Revenue may also be invested in public transit improvements, particularly targeted at corridors affected by the cordon zone. Such strategies typically are progressive with regards to transportation-disadvantaged individuals who are transit dependent. Since transit vehicles are typically exempt from cordon fees, yet can reap the benefits of improved travel time and reliability, increased investments in transit can provide further benefits for these "captive" riders. This assumes, of course that the transit system is able to handle the increased demand resulting from drivers who avoid the toll by switching to public transit. Revenue redistributed for use in roadway investments may have differential impacts.

Though such roadway improvements could benefit bus-riders utilizing these corridors, it is primarily those drivers in the corridors with the highest absolute travel costs that will benefit the most from roadway investment. In addition, roadway expansion could result in induced demand, thereby reducing the benefits received from this use of cordon pricing revenue in the long run.

In cases of transit or roadway investment, the use of cordon pricing revenue could potentially be considered *revenue neutral* if it offsets more regressive forms of taxation. For example, sales taxes used to fund major transportation infrastructure projects are often funded in part by sales taxes, which are a regressive form of taxation for low-income groups. If cordon pricing revenue replaces funding from such regressive taxes, low-income individuals that do not suffer adverse impacts from cordon pricing toll payment (i.e. they have alternatives to driving) may receive significant benefits, for they will no longer pay for something they may never use. Instead, the burden has been shifted to those who must drive during charging hours, and who therefore contribute more to the negative externalities of traffic congestion. As Taylor and Norton (2009) note, debates regarding social equity concerns of congestion pricing often ignore these existing social inequities in transportation finance systems. They argue that a shift from sales taxes and other non-user fees, to a pricing system that charge users during peak periods would shift the burden away from lower-income travelers as a group. Yet this line of argument fails to recognize that even if cordon pricing revenue is utilized to replace existing regressive forms of transport finance, for those low-income individuals with no alternative to driving, the benefits of reduced sales tax burden must be weighed against the burden imposed by cordon fee payment.

Conclusions on Cordon Pricing Mitigation

The highly spatial nature of cordon pricing systems, accompanied with issues of fee payment and the distribution of revenue from these systems makes such strategies the target of equity-based complaints. The disproportionate impacts of cordon pricing on low-income automobile-dependent peak-period commuters in areas with poor accessibility to alternative modes illustrate the importance of considering community-level spatial-equity concerns, in addition to income and modal equity, when contextually analyzing such pricing strategies and proposed methods for mitigating disproportionate impacts. As Levinson (2009) notes, however, overall the theoretical and empirical literature on the equity impacts of pricing are mixed and depend on the definitions of equity employed. The notion of what is "equitable" is far from easy to define, however, and is highly contested and influenced by a numbers of factors. As Taylor and Norton (2009) highlight, the concept of equity is "defined quite differently by different interests at different times" (p. 22). They argue that such conflicts in definition are the result of philosophical differences regarding the notion of justice, as well as the unit of analysis under consideration (i.e. individuals, groups or jurisdictions). The following chapter examines these differing conceptualizations of justice in order to provide a basis for evaluating the equity impacts of cordon pricing mitigation.

Chapter 3

JUSTICE THEORY AND TRANSPORTATION

The previous chapter highlights the ways in which costs and benefits from congestion pricing can produce uneven impacts for different individuals and groups, with spatial considerations playing an important role in how these impacts are distributed. Equity-based arguments leveled against such strategies are rooted in the larger philosophical concept of social justice, in particular notions of distributive justice. Determining what constitutes “justice” is important, for such a concept helps to define the standards by which the “fairness” of the distribution of costs and benefits can be evaluated. In order to analyze the equity implications of pricing strategies in transportation, it is therefore essential to provide a definition of justice. The term, however, is challenging to define and has produced a number of various perspectives.

Human beings, as moral agents capable of consciously acting in a moral manner, also have a capacity for a sense of justice as noted by John Rawls. This sense of justice may be based on the individual’s conceptualization of what is considered “fair,” and even a recent study (Wolpert, 2008) by UCLA scientists determined that the human brain responds to being treated “fairly” in much the same way that is reacts to other reward and pleasure stimuli. Exactly what is considered “fair” or “just”, however, may differ significantly. In addition, people often will instinctively switch from one conceptualization of justice to another, based on the given situation, even in ways that may seem internally contradictory or illogical (Taylor & Norton, 2009).

Much of the difficulty associated with defining a theory of justice rests in the tension between demands for equality versus demands for individual liberty. Social justice as it is commonly philosophized involves concerns of equality, while distributive justice considers the equality of the distribution of goods across members of society. The distributive principle of equality can serve as the default criterion upon which the "justness" of such distributions can be judged (Martens, Golub, & Robinson 2012). According to some justice theorists, such as Barry (1989), theories of social justice attempt to identify social arrangements involving unequal treatment or inequality that can be justified and defended. Without convincing justification for inequality, the only correct way to distribute goods is in an equal fashion (Martens et al., 2012). In its strictest sense, therefore, distributive justice argues that people should be as equal as possible in the dimension under consideration, while in a weaker conceptualization equality would be subject to certain limitations based on other values (Martens & Golub, 2012).

Though various theories of justice have been proposed over the years, the lack of consensus on a single theory demonstrates the challenges facing transportation planners, as they must navigate competing and conflicting viewpoints of "justice" in their efforts to balance effectiveness and efficiency with issues of equity. Schweitzer and Valenzuela (2004) note that studies of justice in the realm of transportation tend to focus on distributive justice, examining cost-based or benefits-based claims of injustice. As many justice struggles and debates are centered on issues of who receives the benefits versus who suffers the burdens, this chapter begins by examining four prevailing distributive-based theories of justice: utilitarianism, egalitarianism, contractarianism (Rawlsian), and libertarianism. In addition, alternative and newly emerging theories of justice including resource-based, communitarian, capabilities, and midfare theories are highlighted, as well as theories that go beyond prevailing distributive-based notions, including theories on recognition and participation as key elements of justice. The challenges that are confronted by transportation planners attempting to work within these conflicting paradigms are also highlighted for each.

Utilitarian Theory of Justice

Utilitarian theories of justice focus on the concept of utility—the pleasure, happiness, or preference-satisfaction that is derived from an action or activity. As such, utilitarianism is focused on outcomes, as opposed to the distribution of goods or resources that produce those outcomes. Utilitarianism follows the universalistic welfare-based principle of maximizing *aggregate* utility, or providing the greatest good for the greatest number of people. For a utilitarian, justice can be determined by calculating the "goods" and the "bads" generated from various activities and determining which option provides the greatest net benefit for society as a whole (Liu, 2001).

In the transportation policy realm, similar activities are attempted in the form of cost-benefits analyses, which attempt to compare policies and the aggregated impacts they will have on society. Such a quantitative approach is intuitively appealing, for it provides a common currency for which to compare different outcomes of different actions and is therefore attractive for use in the policy-making realm. As noted by Martens and Golub (2012), welfare-based approaches, with the implicit focus on derived satisfaction, can hence be interpreted in transport policy as focused on the satisfaction resulting from travel itself, or that which is derived from travel and the activity participation it provides.

Utilitarian theories of justice, however, also have significant weaknesses and limitations, particularly when applied to distributive issues of environmental justice and the way that environmental "goods" and "bads" are spatially located. The infamous Summers

Memo regarding the export of "dirty" industry to "under-polluted" regions of the developing world was written from a strictly utilitarian perspective, which would consider such a situation as just, so long as overall worldwide utility was improved (though perhaps at the expense of the least advantaged). As such, utilitarian theories of justice are not concerned with achieving any Pareto improvements in the position of all groups in society, whereby no one loses and at least one group gains (Liu, 2001). Under a utilitarian viewpoint, even if one group receives significant burdens, this is not important as long as society as a whole experiences net benefits. In this respect utilitarianism is more akin to achieving Kaldor-Hicks improvement, whereby a policy can be justified if the allocation of resources improves the wealth (rather than utility) of society, and if those who gain can *potentially* provide compensation to those who lose, thereby allowing for a possible (though not required) Pareto improvement. By not requiring that compensation be made, only that there is the potential for such compensation, an outcome deemed as "efficient" could result in some people being worse off (Liu, 2001). Such an approach leads to a moral criticism of utilitarian theory, in that it attempts to take a principle that is prudent to individuals and apply it to society as a whole. An individual, facing various choices in life, attempts to make decisions that maximize their overall happiness over the course of their lifetime—maximizing aggregate utility. In such a situation there are no losers, only one winner. When applied to society as a whole, however, different individuals will benefit while others may inevitably suffer.

In transportation policy, all projects create costs and benefits. Such is the case of infrastructure projects (freeway construction, airport expansion, etc.) that may dislocate neighboring disadvantaged communities in order to benefit the good of the overall public, or regional taxes that place a regressive burden on low-income groups in order to fund projects in specific places. In addition to moral criticisms of such practices, utilitarian methods used in transportation planning, such as cost-benefit analyses, utilize complicated quantification techniques that lack objectivity, are inflexible, can be manipulated, and fail to deal with distributive justice concerns. Finally, as Martens and Golub (2012) note, the application of a welfare-based approach focused on outcome satisfaction or pleasure is complicated by offensive tastes (i.e. pleasure derived from activities that discriminate or impede the liberty of others) and by expensive tastes (i.e. the differences in pleasure that different people experience from the same level of resources), not to mention the difficult notion of how to "measure" such satisfaction derived.

Egalitarian Theory of Justice

Egalitarian theories of justice attempt to address distributive issues of justice, which utilitarianism ignores. As with utilitarianism, egalitarian theories are also focused on outcomes resulting from the distribution of goods and services. Egalitarian theorists, however, recognize existing inequalities and consider these unnecessary and unjustifiable. As such, the end goal from an egalitarian viewpoint is to eliminate existing inequality altogether (Liu, 2001). Strict egalitarians are therefore focused on equality of outcomes, in which each individual receives the amount of goods or services that would result in similar conditions of need and abundance (Taylor & Norton, 2009). An egalitarian would consider something "just" if it helps to reduce current levels of inequality in society. As such, this theory of justice focuses on the *relative* position of the least advantaged.

Within the realm of public policy, if a proposal resulted in an outcome where the least advantaged (e.g. the lowest income) received greater benefits relative to any other income group, the policy would be considered just from an egalitarian perspective. This is due to the fact that the outcome of the policy helps to "level the playing field" by providing greater benefits to those already suffering from existing inequality. Under such a scenario, it is not important whether aggregate utility is maximized, only so long as the least advantaged fair better than other groups. In addition, in the case of policies that result in burdens (such as the implementation of a new tax), improvements in the condition of the least advantaged are not required so long as all other groups suffer greater outcome burdens, thereby still helping to level the playing field.

From an environmental justice standpoint, particularly regarding transportation policy and planning, egalitarian theory is relevant. Egalitarian theorists recognize the importance of correcting past injustices by attempting to level the playing field and redistribute benefits to those previously receiving disproportionate burdens, or lacking benefits. When examining justice in transportation this is an important consideration, as transportation infrastructure investments can leave long-lasting impacts on communities and a legacy of unjust burden versus benefit distribution for disadvantaged groups.

Egalitarian theory, however, has significant shortcomings as well. Beyond the moral criticism that egalitarianism unduly restricts freedom and conflicts with what people deserve (a notion addressed by desert-based theories of justice), in addition to ignoring that individual preferences are not equal and that "wants" and "needs" may differ, egalitarian theories also have certain weaknesses from a welfare perspective. By focusing primarily on reducing all inequality as an ultimate goal, egalitarian theorists fail to account for the fact that everyone may be materially better off if incomes are not strictly equal. In addition, from a transportation-policy perspective, by concentrating on the relative position of the least advantaged egalitarian theorists would consider a policy to be "just" so long as it benefits the least advantaged more than any other group. Such a standpoint does not recognize other potential policies that may benefit the wealthy more than the poor as being just, even if these policies would provide greater benefits to the poor than their current situation. For example, if a new transportation investment is primarily utilized by more advantaged groups, thereby providing them with significant outcome benefits, yet the investment also results in benefits that exceed the burdens placed on the least advantaged (thereby improving their current situation), such a policy would still be considered unjust from an egalitarian perspective. This is due to the relative comparison, in which the advantaged receive greater benefits than the least advantaged. For environmental justice advocates attempting to improve the situation of disadvantaged communities, concerns over whether advantaged communities receive *more* benefits than disadvantaged communities may seem irrelevant, so long as the proposed policy advances the position of the disadvantaged the *most* from the current situation. By focusing strictly on reducing inequality between groups, egalitarians fail to consider the *absolute* position of the least advantaged.

Contractarian (Rawlsian) Theory of Justice

Contractarian or Rawlsian theories of justice take into account the absolute position of the least advantaged in society and thereby attempt to address the shortcomings of egalitarianism. In his book *Theory of Justice*, Rawls (1971) contends that if all people worked from behind what he refers to as a "veil of ignorance," in which all people are ignorant of the talents, abilities, and resources of each individual (including themselves) they would reach a consensus (a social contract) regarding the fundamental principles for organizing and evaluating the basic institutions of society from which primary social goods are distributed. Such primary goods include: (a) a set of basic rights and liberties; (b) freedom of movement and free choice of occupation; (c) powers and prerogatives of offices; (d) income and wealth; and (e) the social basis of self-respect. In such a system, rational individuals working from behind the veil of ignorance would chose two justice principles upon which to structure society and distribute this set of goods. The first principle, equal liberty, says that each person has an equal right to the most extensive liberties that are compatible with similar liberties for all. The second principle, the difference principle, is based on the Maxi-min Rule in which individuals behind the veil of ignorance would choose the alternative whose worst possible outcome is at least as good as the worst possible outcome of any other alternative. As such, rational individuals would select a system in which "social and economic inequalities [of primary goods such as liberty and opportunity, income and wealth] are to be arranged so that they are both (a) to the greatest benefit of the least advantaged…and (b) attached to offices and positions open to all under fair equality of opportunity" (Rawls, 1971, p. 302).

The principles provided in Rawlsian theories of justice are useful for environmental justice policy analysis, for they provide rules concerning the "justness" of actions taken by societal institutions (Schlosberg, 2007). This same strength, however, can also be a hindrance for environmental justice advocates, as it pays less attention to the actual consequences of these actions and fails to provide a way of evaluating policy alternatives in the way that utilitarian cost-benefit analyses provide (Liu, 2001). As such, the difference principle of contractarianism is focused on equity of opportunity, as opposed to equity of outcome (Taylor & Norton, 2009). Also, unlike egalitarian goals of eliminating inequalities, a contractarian viewpoint would find increasing inequality not to be a problem, so long as the absolute position of the least advantaged is improved the most. The maximization of overall aggregate utility is also not a stated goal of Rawlsian justice theory, nor do such theories consider the issue of what people "deserve." Also, as Martens and Golub (2012) note, the difference principle is only concerned with the distribution of social primary goods, not with the distribution of other socially desirable goods, such as transportation. Any attempts to apply Rawlsian theory of justice directly to distributive outcomes of transportation would therefore require examining the relationship between transport and the primary goods distinguished by Rawls.

Harvey (1973) takes a contractarian approach by addressing the absolute position of the least advantaged, but from a spatial perspective. He defines a just or equitable territorial distribution as meeting the needs of each territory, allocated in a way that rewards contribution to the common good while helping overcome spatial difficulties so that the prospects of the least advantaged territories are maximized. Such an approach illustrates the way in which principles of defining distributive justice vary not only by philosophical theory, but also by the unit of distribution (i.e. individual, group, or geographic area) as highlighted by Taylor and Norton (2009).

Libertarian Theory of Justice

Utilitarian, egalitarian, and contractarian theories of justice all share a common criticism among libertarian justice theorists, in that they unduly restrict freedom and infringe on individual liberty by specifying the distribution of outcomes. Under a libertarian viewpoint of justice, individuals should be allowed to do as they want, without coercion or fraud, so long as they respect this same right of other individuals (Wenz, 1988).

Libertarianism does not propose a desired distribution pattern *per se*, but instead describes the sorts of acquisitions or exchanges which are themselves considered to be just. According to such theorists, a distribution is just if everyone is entitled to the holdings they possess—through just acquisition and transfer (Taylor & Norton, 2009). As such, government cannot legitimately intervene in the operation of markets except to prevent fraud or coercion. With regards to issues of environmental justice, libertarianism assumes that through the allocation of private property rights and voluntary transactions made in the free market, individuals will solve conflicts involving environmental nuisance or trespass through voluntary bargaining (Liu, 2001).

Numerous criticisms, however, have been lodged against libertarianism as a theory of justice (Wenz, 1988; Liu, 2001). First of all in the case of environmental externalities, libertarians fail to consider such market failures that involve numerous sources and cannot be solved through individual bargaining in the free market (Liu, 2001). In the transportation realm for example, serious environmental externalities such as air pollution are the result of numerous individual mobile sources while the impacts are felt across all members of society (though perhaps to varying degrees depending on individual vulnerability). In such a case, voluntary bargaining between individuals over a collective good (i.e. fresh air) is not possible, as property rights are not clearly defined, as assumed under libertarian theory (Liu, 2001). More fundamentally, however, libertarian theorists ignore the fact that the original acquisition of environmental resources on which current property rights (and libertarian theory) are based may very well have involved the use of force or fraud. As such, it fails to adequately account for past injustices involving unfair acquisition and transfer of property (Wenz, 1988).

Although the four classic theories of justice discussed in the previous section offer certain advantages for analyzing justice issues in the realm of transportation, their numerous weaknesses make their direct application to transport policy inherently difficult. In response to the limitations of these theories, other alternative theoretical approaches have been presented to rectify these shortcomings. The following sections present a few of these alternative theories, and examine their potential application to transportation-related issues.

Resource-Based Theories of Justice

Unlike utilitarianism and other welfare-based approaches, resource-based theories of justice, such as posited by Dworkin (1981a; 1981b), focus on equality of opportunity rather than outcomes. Yet unlike the Rawlsian difference principle, which allows for inequality in the distribution of primary goods, resource-based theories focus on equality in the distribution of resources. These resources are theorized as not only material goods and services, but also mental and physical capabilities. Dworkin (1981b) and other resource-based theorists advocate for an initial equal distribution of resources, with compensation provided for individuals having deficiencies (e.g. lacking abilities or talents) in those resources at the outset. Resource-based theorists, however, call for little or no cross-subsidization following initial allocation, thereby expecting and accepting unequal outcomes (Taylor & Norton, 2009). Resource-based theories, when applied to the transportation realm, imply a focus exclusively on the distribution of transportation resources (and hence the potential mobility they provide), not on the welfare derived from actual use of these transportation resources and the activity participation that results (Martens & Golub, 2012).

Critics of resource-based theories note that such an exclusive focus on initial equality of resource distribution fails to account for the way in which these resources actually benefit different individuals. In addition, such theories do not recognize the circumstantial differences between those receiving the resources and how these variations may affect their ability to utilize them in a useful way (Taylor & Norton, 2009). In the field of transport, by focusing on the potential mobility provided by transportation resources, such a theory ignores how these resources allow individuals to participate in activities as a result (Martens & Golub, 2012). In other words, resource-based theories ignore how resources impact the capability of an individual to transform the resources into something of use or value. In response to these shortcomings, capabilities theories of justice attempt to explicitly recognize such considerations.

Capabilities Theory of Justice

Capabilities theory of justice, as articulated by Nussbaum and Sen (1992), focuses not on the distribution of a set of primary goods, nor does it prescribe a specific distributive pattern that would be considered "just." Highlighting this point, Sen (1980) argues that differentially situated people require different amounts of resources to satisfy the same needs. By focusing strictly on the equality of distribution of resources, distributive justice theorists do not recognize the important role of needs-satisfaction played by these goods, nor do they account for the variation in needs-satisfaction that can occur based on factors unique to each individual and their situation. As such, they do not consider the way in which distributions affect the well-being and functioning of individual agents (Schlosberg, 2007). Capabilities theory, while still recognizing the central role that distribution plays as a component of justice, focuses on a basic set of capabilities all individuals are entitled to as a prerequisite for a just society. These capabilities act as the things that allow individuals to translate basic goods into human functioning. As such, the focus moves from the goods that individuals get, to a focus on what these goods actually "do" for the individual (Schlosberg, 2007). Although Sen (1999) provides five elements that advance human capabilities, they are broad in scope. He later notes a reluctance to distinguish a particular list of capabilities due to the paternalism of such an approach, as well as the contextual nature within which such a list should be developed through public participation and deliberation (Sen, 2005). Nussbaum (2003), however, does distinguish a list of ten abstract universal capabilities, though Martens and Golub (2012) note that even though freedom of movement is identified as one of Nussbaum's basic human capabilities, direct conclusions cannot be drawn regarding the way transportation-related goods are distributed.

Schlosberg (2007) notes that capabilities theory helps expand notions of injustice beyond considerations of how goods needed to flourish are distributed or denied, to a conceptualization of how capability to flourish is limited by such distributions. As such, these theories combine concerns over equality of resources (opportunities) with issues of equality of welfare (outcomes). Such theories, however, are not without their limitations. As Cohen (1993) contends, the concept of capabilities is too imprecise. In place of capabilities, Cohen calls for a conceptualization referred to as 'midfare.'

'Midfare' Theory of Justice

Midfare, as theorized by Cohen (1993), falls midway between having goods and having utility or welfare, hence the name given. He notes that capabilities, though important to the concept of midfare, do not encompass all of its elements, since certain goods that may not enhance the capability of an individual, may nonetheless provide them with welfare. By focusing on the well-being of a person, midfare recognizes that the amount of utility a person receives is only an indication of their well-being, while the goods and resources they have available are only causes for their well-being (Martens & Golub, 2012).

In the realm of transportation, numerous circumstances influence the ability of an individual to translate the goods or resources they receive (i.e. their potential mobility) into welfare (i.e. activity participation). As such, Martens and Golub (2012) contend that midfare is the "extent to which a person is able to translate transport resources into the possibility to participate in activities" (p. 204), and is determined in part by land use patterns and the spatial distribution of individuals and their various needs, as well as by personal circumstances and commitments that influence the individual's ability to participate in types of activities. They highlight the importance under such a midfare approach of addressing the spatial context and particular needs of communities in order to analyze transportation equity. Since the concepts of potential mobility and activity involvement lie at either end of the continuum between goods and utility, Martens and Golub (2012) analyze the concepts of access (a characteristic of a person) and accessibility (a characteristic of an activity location) and their methods of measurement by utilizing the midfare approach. They conclude that different accessibility measures partially comply with the components of the midfare concept, with additional research needed to determine which performance indicator is most appropriate for equity analysis in transport planning practice.

To further illustrate the justification for utilizing the concept of 'access' as an appropriate measurement for transport equity analysis, particularly in light of issues of spatial context and community need, Walzer's (1983) 'Spheres of Justice' provide additional insight from a perspective on distributive justice that recognizes the unique social meaning of the transport 'good' and what it provides.

Communitarianism—Walzer's 'Spheres of Justice'

Unlike other prevalent theories of distributive justice, Walzer (1983) does not present a universalizing criterion for the distribution of an abstract set of basic goods, but instead views goods as having different social meanings attached to them that should guide the principles for distributing such goods. Unlike regular goods, which can be distributed through the free market, goods with distinct social meaning should be given their own autonomous distributive "sphere" (free from influence of other goods distribution) in which principles for distribution are appropriate for that particular good based on its social meaning. As such, though inequalities can and will exist within a particular sphere these inequalities will not affect distributive outcomes of non-regular goods within other spheres.

From a transportation justice standpoint, Martens (2008) argues that transportation should be considered its own separate sphere with the social meaning based on the access it provides. As such, principles of distribution within the transportation sphere are not appropriately distributed along egalitarian lines of equality (for this is essentially not possible in the core-periphery spatial arrangements of today), nor along lines based on what individuals "deserve" (for any claims of desert for transportation are weak) or what they "need" (which is problematic to define), and should instead be determined by identifying a criterion that matches the "particularities of the transport good" (Martens, 2008, p. 13). He defines the 'maximax' criterion as an appropriate principle for the distribution of access, whereby the goal of maximizing average access is limited by a maximum allowable gap in access levels between the worst-off and the best-off. Such a distributional criterion can serve as a useful tool for transportation planners attempting to address issues of equity in planning practice. Some theorists, however, contend that a distributive focus such as this still only provides a partial understanding of the justice issues faced by disadvantaged groups. The following section highlights this critique of distributive justice theories.

Recognition and Participation

In recent years, prevailing theories of justice have been criticized for their focus on the distribution of opportunities or outcomes, while ignoring issues of recognition and representation. Young (1990) for example highlights the issue of domination and oppression imbedded in formalized institutions and day-to-day practices that lead to such "unjust" distributions. She states that different participatory structures encouraging genuine representation of all perspectives are necessary to truly achieve social justice. Schlosberg (2007) goes beyond Young's notions of procedural participation to include the actual recognition of individuals, groups and communities and their ability to express and exercise their capabilities as equally important theoretical components of justice. He emphasizes that distributive paradigms do not need to be replaced *per se*, but should be combined and complimented with such concerns. Considerations of recognition and participation are quite significant in the realm of transportation planning and environmental justice. Without the needs of unique groups being recognized in the planning process and without adequate representation and participation in decision-making, unjust distributions of burdens and benefits in the transportation sector are not likely to improve. Though these considerations can further shed light on issues of environmental injustice, for purposes of this research justice will be considered from a distributive perspective. Considerations of just process and recognition are beyond the scope of this project and provide potential opportunities for future research.

Table 1

Summary of philosophical theories of distributive justice

Theory of Justice	Conceptualization of Justice
Utilitarian	Focused on welfare-based outcome goal of maximizing aggregate utility defined as the pleasure, happiness, or preference-satisfaction derived from an action or activity
Egalitarian	Focused on welfare-based outcome goal of eliminating existing inequalities and improving the relative position of the least advantaged
Contractarian	Focused on equality of opportunity in societal institutions that distribute primary social goods, while allowing for differences that are to the greatest benefits of the least advantaged (the absolute position)
Libertarian	Focused on the just consensual acquisition and exchange of property between individuals in the market, free from fraud or coercion
Resource-based	Focused on equality of opportunity in which resources are distributed to individuals at the outset, with no cross-subsidization afterward
Capabilities	Focuses on equality of capabilities all individuals are entitled to, and which act as the things that allow individuals to translate basic goods into human functioning
Midfare	Focuses on "well-being" as a middle ground between resources and utility, recognizing that utility received is only an indication of well-being, while goods and resources distributed are only causes for well-being
Communitarian	Views certain goods as having different social meanings attached to them that should guide the principles for distributing such goods

Conclusions on Justice Theory in Transportation

The previous sections illustrate the varied, often conflicting, philosophical ways in which the concept of distribute justice can be theorized, as summarized in Table 1. They also demonstrate the wide variety of methods for analyzing the "fairness" of transportation policies and programs through these diverse distributive justice lenses. For planners attempting to address issues of income, modal, and spatial equity in transportation by mitigating disproportionate impacts on the disadvantaged, the question remains: How can the divergent viewpoints of justice be applied to issues of equity in transport policy, and how can the goal of achieving equity be balanced with the objectives of efficiency and effectiveness? Taylor and Norton (2009) argue that neither a totalist perspective (viewing one justice theory as objectively "correct"), nor a political pluralist perspective (recognizing inherent self-interest and inevitable conflict that results) are necessary when defining the concept of equity in transport pricing and finance. They contend that selfish individuals may act selflessly and accept redistributive policies that benefit the disadvantaged and support the collective good as a form of social insurance (for their potential own benefit). In order to assess how well such policies may support the collective good, they note that likely outcomes and goals of policies must be determined, yet they argue that efficiency and effectiveness of policies are not necessarily incongruent with notions of equity. The following section discusses how a conceptualization of equitable distribution can be formulated, and how different distribute justice theorists might interpret equity under such a framework.

Transportation Equity within a Distributive Justice Framework

Within a distributive perspective of justice, the concept of equity can be used as a criterion upon which justice theory can be applied to judge the "fairness" of distributions. As a result, the concept of equity, as noted by Viegas (2001) and Ungemah (2007), can have various definitions and interpretations. Within the realm of transportation, Ecola and Light (2009) review numerous studies of transportation equity from a welfare-based standpoint (often used by transportation economists and involving complex modeling of hypothetical situations) and a social justice-based standpoint (often used by transportation planners and social scientists to assess impacts on disadvantaged groups). They note that such varied forms of research using differing approaches and based on subjective aspects can result in conflicting conclusions. As Litman (2007) points out, these differing results can all be legitimate based on the definition of equity used and it is up to the local community to determine which criteria are appropriate for evaluating the equity of transportation policies.

In policy analysis, two dimensions of equity are often considered. The first dimension, horizontal equity, examines the relative comparison between members of the same group, while the second, vertical equity, looks at the relative comparison between members of different groups. Under such a conceptualization, it is important to recognize differences in the rationale behind the distribution (strongly dictated by distributive justice theory), as well as among whom the distribution will take place, whether it is between individuals, groups, or geographic areas. Taylor and Norton (2009) note that equity among individuals is often the focus of social science scholars in transport, advocates and activists tend to emphasize group equity, while elected officials focus primarily on geographic equity between jurisdictions. Such differences are essential to recognize as they may lead to divergent equity analysis results.

Within the realm of transportation, Litman (2007) provides a classification of equity that further elaborates the notions of horizontal and vertical equity, but among three major categories: horizontal equity, vertical equity with regard to income and social class, and vertical equity with regard to mobility need and ability. Such a classification is highly useful for equity analysis in transportation, as it allows for the consideration of income, modal and spatial equity concerns in a combined framework. These three categories, as conceptualized by Golub and Kelley (2010), can be thought of as “planes of equity” (Figure 3). Along the horizontal plane involves the distribution of transportation impacts among individuals or groups of equal ability and need. In transportation, analysis along such a plane would examine how individuals or groups of similar income and wealth (economic advantages), and those of similar mobility need and ability (transportation advantages) compare relative to one another. As such, the horizontal plane could be considered as connoting spatial or geographic differences between these individuals or groups, in particular how these differences influence their access to the transportation system (opportunities) and the activity participation it allows for (outcomes).

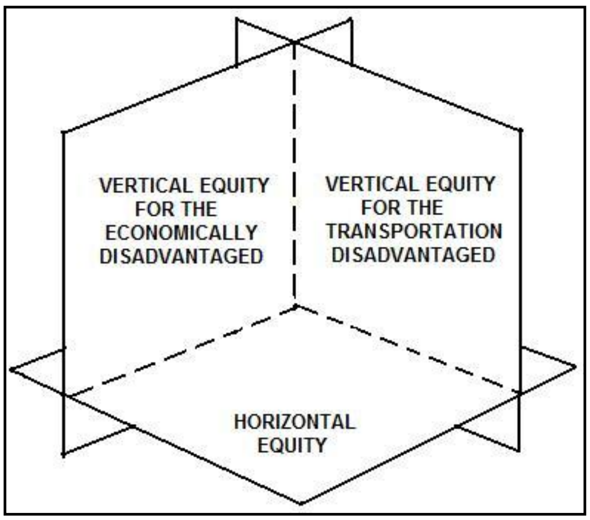

Figure 3. “Planes” of equity.

Meanwhile, two different vertical equity planes, often in conflict with and overlapping horizontal equity, concern the distribution of impacts with regard to those of unequal income and social class, and among those of unequal mobility need and ability. These two vertical planes can also overlap, because many transportation disadvantaged individuals are also economically disadvantaged and vice versa. These vertical planes can also conflict, as in the case of wealthier individuals or groups lacking mobility compared with low-income groups or individuals with relatively high levels of mobility.

What is inherent in such as conceptualization, is that the tradeoffs between variations in income (or wealth), mobility, and geography produce the degree to which individuals or groups have access to opportunities and the outcomes they provide. As providing access is the primary purpose of transportation, these planes of equity can assist transportation planners in understanding the equity impacts of transport investments and policy decisions. These three planes of equity help provide a way for comparing different individuals and groups, across varying geographic areas. When the viewpoints of distributive justice theorists are then applied to this model, it can be utilized to explain differential interpretations of what is "equitable" in transport policy from the various opposing schools of distributive justice theory.

For example, equity principles theoretically based on Rawls' (1971) argument that primary social goods (liberty, opportunity and wealth) should be distributed in a way that improves the absolute position of the least advantaged would be particularly concerned with equity along the horizontal plane, since no relative comparison to more advantaged groups is necessary under contractarian philosophy. Under such logic, horizontally equitable transportation policies should therefore improve the position of economically and transportation-disadvantaged individuals and groups. As such, transportation equity objectives from a contractarian viewpoint could include the provision of services (opportunities) that benefit the most disadvantaged by providing access, such as improvements made to basic access to necessities (medical facilities, schools, employment, etc.). Under a contractarian viewpoint, however, the impacts of such service provisions on more advantaged groups are not a concern, and differences between groups (along the vertical planes) are not a necessary comparison.

An egalitarian viewpoint of distributive justice would concentrate attention primarily along the vertical planes. As an egalitarian is mostly concerned with the position of the least advantaged relative to other groups, such a theorist would examine how transportation policy impacts the differences that exist between people of different groups. Under an egalitarian viewpoint, the provision of transportation services should provide benefits that reduce the existing inequalities between the most and least-advantaged. An example of such a policy would be the implementation of transportation funding mechanisms that are progressive in nature, as opposed to regressive finance strategies (e.g. sales taxes) that place a disproportionate burden on the poor.

The planes of equity discussed in this section provide a useful way for comparing differential impacts among groups and individuals, across geographic areas. By applying the distributive justice theories to these planes of equity, a conceptual framework for assessing the distribution of costs and benefits associated with transport policy emerges. This framework can also serve beneficial for planners dealing with equity concerns generated by proposed transportation pricing strategies and the mitigation options available to address such issues.

Analyzing the equity impacts of transportation policy, however, is not the only responsibility of transportation planners, as they must also consider issues of program efficiency and effectiveness. Chapter 2 introduced the notions of efficiency and effectiveness, particularly as they relate to congestion pricing, and these concepts can be applied to transport policy in general. As noted by Taylor and Norton (2009), the efficiency and effectiveness of the performance of a transportation program itself can be analyzed, focusing on its effectiveness at maximizing political acceptability and revenue generation, while efficiently minimizing related administrative costs. An alternative approach emphasizes the impacts of the program on the performance of the transportation system itself, focusing on its effectiveness at lowering transportation costs and optimizing the utilization of existing capacity, while efficiently optimizing transportation service at a given level of expenditure. Planners must therefore consider the effectiveness and efficiency of both the program itself and the impacts of the program on system performance, in conjunction with considerations of horizontal and vertical equity, in order to have a full understanding of the impacts of transport policy. Figure 4 illustrates these considerations in transportation planning, and the trade-offs that may occur between them.

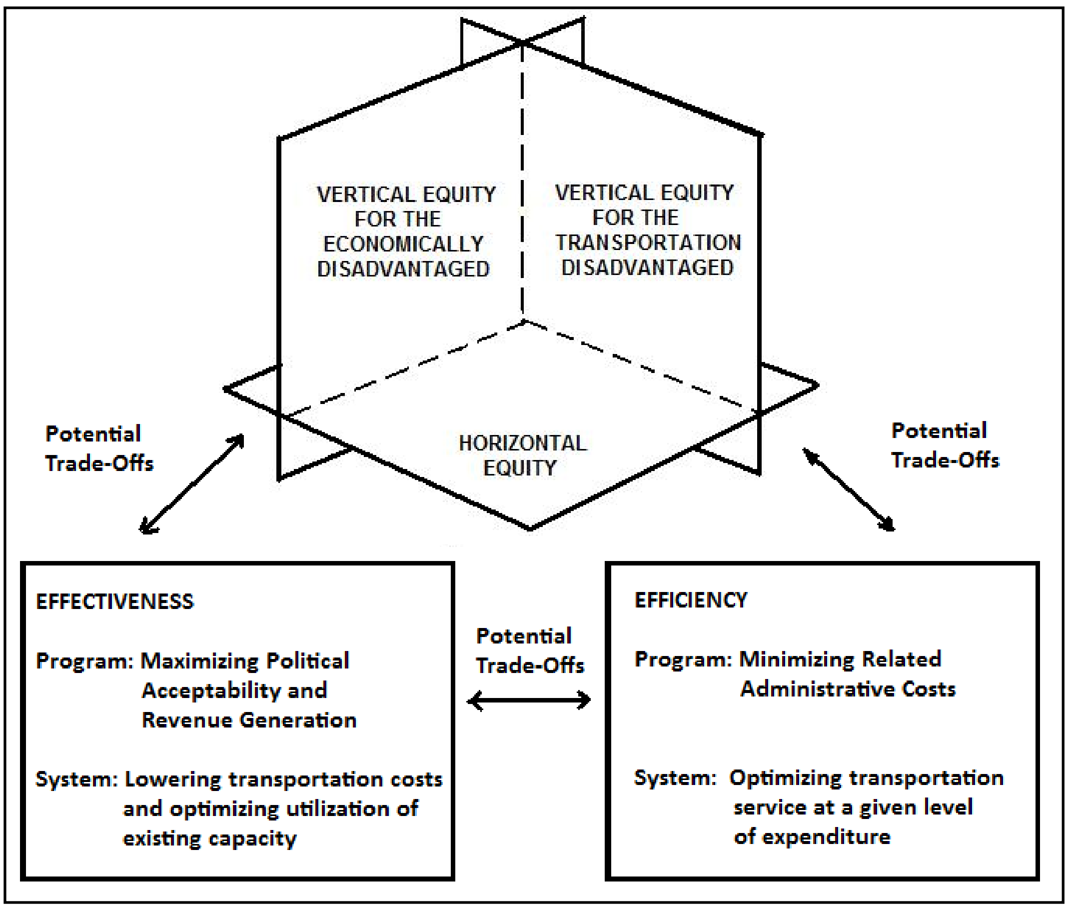

Figure 4. Equity, efficiency, and effectiveness consideration in transport policy.

Although the conceptualization of equity presented in this section is helpful, planners must also be conscious of the legislative, executive, and judicial action that has been taken in the realm of transportation equity in order to address such concerns. The following section provides an overview of these considerations and how attention by the US government has helped to shape the way in which equity is perceived, regulated, and addressed within the transport realm.

Legislative, Executive, and Judicial Action on Transportation Equity

Though the conceptualization of equitable distribution presented in the previous section may be useful for evaluating transportation policies and their impacts on individuals and groups in society, it inconsistently overlaps and in some cases contradicts the way in which "equity" is articulated within the acts of the federal government that serve as the legal foundation for environmental justice in the United States. The following sections highlight some of the most significant legislative, executive, and judicial attention given to issues of equity that are highly relevant in the transport realm.

Title VI of the Civil Rights Act of 1964

Title VI of the Civil Rights Act of 1964 was the first important action of the federal government that would lead to the incorporation of social equity concerns into transportation planning and policy making. This title prohibits discrimination based on race, color, or national origin in federal financially-assisted programs and activities and authorizes and directs federal agencies to take action to carry out this policy. As an act of Congress, Title VI also provides an important legal remedy and recourse for discriminatory actions (Gordon & Harley, 2005). For transportation planners working on federally-funded programs, or in states with their own Title VI requirements, such considerations are therefore important to be aware of and recognize.

The wording of Title VI, however, provides only limited guidance for defining actions that are “discriminatory” in nature, while from a distributive perspective it does not specifically detail what distribution of burdens and benefits would be considered unjust (Gordon & Harley, 2005). Title VI §601 of the Civil Rights Act (1964), for example, states “No person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance” While explicitly forbidding exclusion from process participation and denial of benefits, Title VI does not specify what an equitable distributive outcome would look like. This creates challenges when attempting to apply a conceptualization of equity within the Title VI framework. Though horizontal equity concerns could potentially be addressed with the anti-discriminatory focus of the title (thereby possibly alleviating unjustifiable favoritism toward a particular group), vertical equity objectives are not necessarily advanced by Title VI. The loose definition of “discrimination” provided by the title is at the root of this problem.

Title VI makes no specific delineation between intentional vs. unintentional discrimination. As such, the US Supreme Court decision in *Sandoval v. Alexander* interpreted discrimination under Title VI as only involving cases of actual *intent* to discriminate. This decision effectively closed the door to lawsuits filed by private persons against federally-funded agencies for discrimination cases involving disparate impact in which intent could not be explicitly demonstrated—the so called “smoking-gun dilemma” of Title VI (Gordon & Harley, 2005). This has significant implications from a distributive equity perspective, because activities that unintentionally discriminate against disadvantaged groups can very well lead to inequitable distribution of burdens and benefits. In addition, it should be noted that Title VI makes no specific mention of issues regarding income and only addresses discrimination based on race, color and national origin. As a result, Title VI does not directly address vertical equity concerns for economically disadvantage groups (though indirectly it could be argued that minority groups in the US are disproportionately represented among the economically disadvantaged).

Executive Order 12989

Though the Sandoval case limited the types of legal recourse available in Title VI cases, individual actions within the executive branch of government and the specific federal agencies have provided further opportunities for addressing issues of vertical equity. President Clinton's (1994) Executive Order (EO) 12898 helped to extend the realm of equity to include those of low income by requiring that federal agencies design procedures that make achieving environmental justice part of their basic mission. More specifically the EO states "each federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the US" (Clinton, 1994). Unlike Title VI, EO 12898 incorporates a more explicit definition of distributive justice by highlighting the consideration of "disproportionate" effects rather than mere intentional forms of discrimination. This definition, particularly when considering the distribution of transportation *burdens,* fits more closely into the conceptualization of vertical equity for it prevents the least advantaged from suffering a larger share of the burdens than more advantaged groups. It also provides additional protection for the "economically disadvantaged" through its explicit recognition of low-income groups. From a distributive *benefits* perspective, however, the implications of EO 12898 are less clear. Though §2-2 of the EO requires federal agencies to conduct activities in a manner that does not exclude individuals or groups from participation, subject them to discrimination, or deny them the benefits of such programs, policies and activities, the EO does not go beyond this loose definition to provide specific principles for benefits distribution. This illustrates a dilemma, for even if benefits are not explicitly "denied" to a group or individual, the proportion of benefits received may still be considered inequitable. For example, if a policy or program were to result in a welfare improvement for all groups, yet the benefits of the least advantaged are minimal while those of the most advantaged are disproportionately larger, the EO objectives could still be considered achieved. This hardly fits well with the horizontal equity plane under a contractarian viewpoint, for the absolute position of the least advantaged in such a situation would improve only minimally. In addition, EO 12898 does not create a new form of legal recourse for cases of inequitable distribution, because it is only an internal management tool of the executive branch. Instead EO 12898 recommends that Title VI be used to pursue legal remedies for environmental injustices (Gordon & Harley, 2005).

Actions of Federal Agencies

Though Title VI and EO 12898 helped provide the foundation for examining issues of inequitable distribution in transportation planning and policy-making, the way in which these legislative and executive actions have been interpreted and applied within Federal agencies is also important to consider. In response to EO 12898, the Department of

Transportation (DOT), the Federal Highway Administration (FHWA), and the Federal Transit Administration (FTA) have each adopted directives that clarify the types of distribution considered equitable and the agency-level procedures for achieving these distributive goals. The first DOT directive on EJ in 1997 (the Department of Transportation Order to Address Environmental Justice in Minority Populations and Low-Income Populations), updated in 2012, provides further clarification of the term "disproportionately high adverse effects" by providing examples of individual/cumulative human health and environmental impacts considered significant (DOT, 2012). These adverse effects include not only environmental externalities of transportation (pollution, resource depletion, aesthetic impacts, displacement, destruction of community cohesion/vitality, and traffic congestion) that are typically recognized as the burdens of transport, but the DOT directive also provides two additional adverse effects related to the benefits of transportation (i.e. accessibility). The directive lists "isolation, exclusion or separation of minority or low-income individuals within a given community or from the broader community; and the denial of, reduction in, or significant delay in the receipt of, benefits of DOT programs, policies, or activities" as being effects of transportation considered adverse (DOT, 2012). In addition to providing clarification on "adverse" effects, the DOT directive also elaborates on the term "disproportionately high" as being an adverse effect that either is or will be predominately borne by a minority and/or a low-income population, and that is "appreciably more severe or greater in magnitude" than the adverse effect suffered by the non-minority and/or non-low-income population.

When applying the planes of equity concept to the DOT directive's definition of equitable distribution, the issue of distributive *benefits* fits more closely under the DOT directive due to the explicit connection established between the accessibility benefits of transportation policy and the "disproportionately high adverse effects" that lack of access to these benefits entails. Also, by incorporating the term "disproportionate" with benefits, mere Pareto improvements (that may primarily benefit the most advantaged and the least advantaged only minimally) are avoided as the concept of "proportionality" is introduced. Proportionality implies that each group should receive a proportionate share of the benefits and burdens of transportation, rather than one group potentially reaping the lion's share of benefits. Proportionality therefore implies that reasonable boundaries exist that would determine if a share is disproportionate or not (Martens & Golub, 2013). From an equity standpoint, while further enhancing the absolute position of the least advantaged along a horizontal equity plane, DOT directive still does not ensure that the relative position of the least advantage will necessarily be improved, nor does it help to "correct" any past injustices inflicted upon such disadvantaged groups. Though the DOT directive and subsequent DOT, FHWA, and FTA memoranda and directives have provided additional considerations for MPOs and transportation planning agencies to improve compliance with Title VI and EO 12898, they do not provide specific standards or guidelines for determining the "equitable" proportionality of benefits and burdens to be distributed.

Other Federal Legislation

Passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1992 also increased the attention to issues of social equity in transportation planning. The law shifted funding discretion to local MPOs, strengthened public participation rules, and effectively redistributed federal transportation resources across a broader range of constituents, placing increased emphasis on alternative transportation modes. At face value, such increased attention and funding toward alternative transport would seem to fit well with the planes of equity, particularly vertical equity for the transportation-disadvantaged. Grengs (2004) notes, however, that from a distributive perspective the least advantaged may actually suffer disproportionately as a result of ISTEA and subsequent follow-up legislation (TEA-21 and SAFETEA-LU). Though ISTEA provides new political openings for constituents in the decision-making process, the needs of the least advantaged (particularly residents concentrated in high-poverty central-city locations) may be overshadowed due to social isolation and ignored by MPOs with a tendency to under-represent the interests of central city residents (Grengs, 2004). As Grengs (2004) summarizes, “By successfully promoting a broader distribution of transportation resources, these welcome revisions in federal policy may be distorting participation and thus intensifying the damaging trends that threaten to deprive low-income people from good job access over the long term” (p.62). This complicates the direct application of Litman’s conceptualization of equity within the context of the procedural statutes within ISTEA. Though the situation for transportation-disadvantaged groups may potentially improve, it is by no means guaranteed under the circumstances of increased and open process participation.

Conclusions on Federal Attention to Transportation Equity

Litman’s (2007) definition of equity in transportation inconsistently overlaps and contradicts the way in which “equity” is articulated within the acts of the federal government that provide the legal foundation for justice, thereby illustrating the limitations of applying such a conceptualization within the legal framework of US transport policy. The idea of horizontal and vertical equity planes, however, still provides a relevant conceptualization of equitable distribution for evaluating transportation policies and their impacts on individuals and groups within a theoretical distribute justice framework. Such a notion of vertical and horizontal equity therefore serves as a useful tool, not only for assessing the potential disproportionate benefits and costs resulting from transportation pricing strategies, but also for analyzing the impacts of mitigation strategies that attempt to alleviate these inequities.

For transportation planners attempting to address concerns of equity in congestion pricing, however, a few questions remain. How well do congestion pricing mitigation strategies alleviate social equity concerns from a distributive justice perspective? Would these strategies help maintain the efficiency and effectiveness of the system while addressing such equity-related issues? In order to examine these questions, a theoretical justice framework for analyzing pricing mitigation strategies from a distributive equity standpoint is presented next.

Theoretical Justice Framework for Pricing Mitigation

The following section provides a framework for analyzing cordon pricing mitigation strategies from a theoretical distributive justice perspective, with equitable distribution determined as one that satisfies all three planes of equity. The usefulness of such a framework rests in the fact that it provides a theoretical foundation upon which to analyze the equity impacts of transport policy decisions. Without such a framework, the ability of planners to achieve the goal of equitable distribution is limited, for mitigation strategies attempting to improve equity may actually work in a counter-productive fashion. It is therefore essential that planners are able to recognize the differing principles of just distribution that underpin notions of equity, and have tools available to compare options for achieving equity goals.

The framework presented here is based on the assumption that those most disadvantaged from a cordon pricing strategy would be low-income car-dependent commuters living or working in areas with poor accessibility to alternative mode choices. This assumption is centered on the notion that, although co-benefits of decreased travel time due to congestion reduction may accrue to low-income drivers, the financial hardship of fee payment exceeds the value of any travel-time savings resulting from congestion pricing for these disadvantaged drivers. This finding is illustrated in the discussion of benefits and costs in Chapter 2, and echoed by Ecola and Light (2009) in their review of academic literature on congestion pricing.

Based on this assumption the framework examines mitigation strategies from the three classic justice lenses: egalitarian, utilitarian, and contractarian. Although these three theories of justice may at times conflict with one another, as noted by Taylor and Norton (2009) there is the potential for agreement between opposing schools of thought. As such, this framework provides planners the opportunity to assess whether proposed mitigation strategies have the potential to simultaneously satisfy multiple justice conceptualizations. Strategies satisfying the requirements of equitable distribution as determined by differing distributive justice theories provide a broader justification for implementation, and can therefore appeal to a wider range of stakeholders and potentially overcome barriers of public and political acceptance. As demonstrated by the failure of New York City's pricing proposal to garner enough political approval, appealing to a broader base of constituents with differing philosophical ideologies may be the deciding factor that determines successful implementation. As such, this framework allows planners to explicitly make the connection between pricing mitigation and prevalent justice theory.

Through the three theoretical justice lenses included within the framework, the mitigation strategy of a blanket discount for low income commuters can be analyzed and compared to an alternative of spatially-informed reinvestment of revenue in transportation-improvement projects targeted at those most disproportionately impacted by tolling fees—low-income automobile-dependent peak-period commuters in areas with poor access to alternative modes (Figure 5).

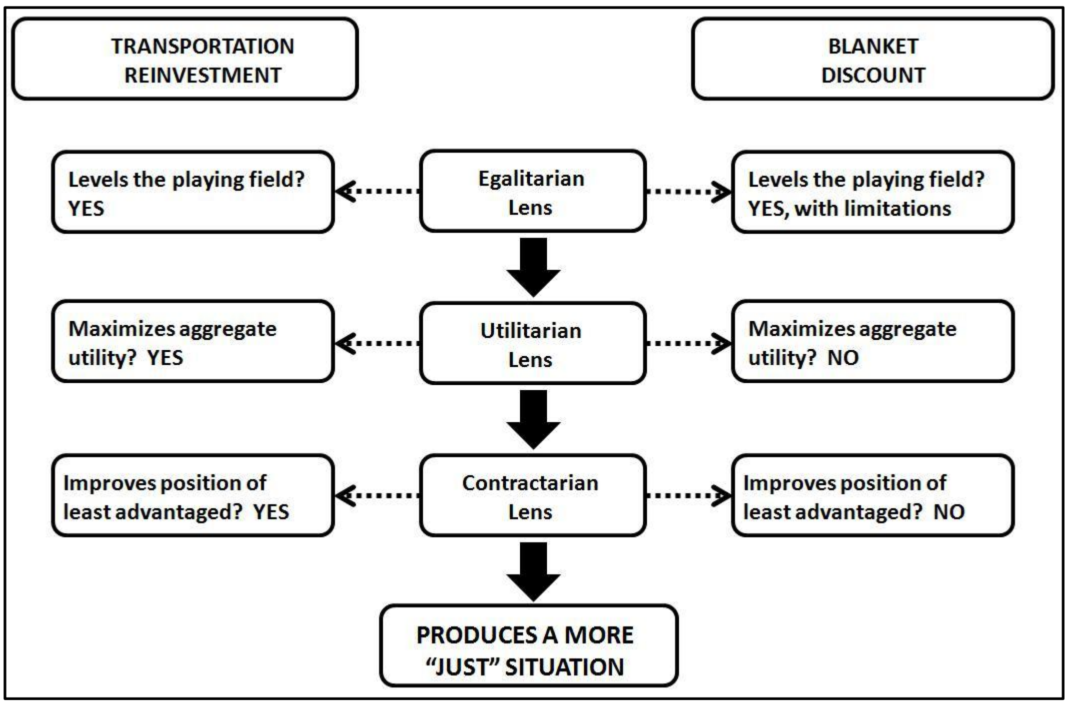

Figure 5. Justice framework for analyzing pricing mitigation strategies.

From an egalitarian perspective, the fee payment impacts of cordon pricing result in an unbalanced playing field upon which certain members (car-dependent commuters lacking alternatives) among those already most disadvantaged (low income) are further burdened by the regressive impacts of the fee payment. The egalitarian lens would therefore require that an appropriate mitigation strategy help to even out this unbalanced playing field by lessening the burden on the most disadvantaged compared to others. From this perspective, a blanket discount to all low-income commuters would indeed provide some relief for the most disadvantaged, since car-depend low income commuters with no alternatives would receive the benefits of a reduced toll (and could *potentially* improve public acceptability and hence increase program effectiveness). A discount would provide no benefits for middle or upper-income commuters and would therefore help improve the position of the least advantaged compared to these groups. It could be noted, however, that such a discount could prove to be a more lucrative benefit for low-income commuters who have a transit alternative, yet decide to drive as a result of the fee discount (thereby also negatively impacting system effectiveness). In such a case a slightly advantaged group (i.e. low-income commuters with mode choices) would benefit more than a lesser advantaged group (such commuters without alternatives) and would therefore not even the playing field in the strictest sense. In addition, although travel time co-benefits typically do not offset the fee payment impacts for low-income drivers, any induced demand caused by the implementation of a discount, and the resulting loss of congestion-reduction co-benefits, must be weighed against the reduced fee payment impacts under discounted pricing. Although not likely to override the benefits of the fee-payment discount under an egalitarian lens, the loss of these co-benefits nonetheless may limit the amount by which the relative positive of the least advantaged is improved.

The second lens is even more problematic for the blanket discount strategy. With the goal of maximizing aggregate utility, any discount provided to a section of the commuting population would at best only eliminate revenue equivalent to the amount of the discount, thereby reducing program effectiveness and efficiency. At worst, such a discount would actually encourage additional driving and work opposite the intended purpose of cordon pricing itself (i.e. to reduce congestion by reducing peak-period driving), thereby reducing system effectiveness and efficiency, as well as decreasing the co-benefits of reduced travel time. As such, a discount strategy would likely result in a reduction in aggregate utility overall.

The final contractarian lens would view a mitigation strategy from the standpoint of the absolute position of the least advantaged. Though no comparison is made to other groups, the position of the least advantaged should not only be improved over the current situation, but by a greater amount than any other alternative strategy. A blanket discount could potentially pass this test, as the least advantaged would receive some benefits in fee reduction over the initial position of full fee payment. Yet, is a blanket discount the type of strategy that would truly elevate the position of these individuals the most, or would the provision of alternative mode choices provide greater benefits for these commuters? If the benefits of opportunity provided by access to mode choices would indeed exceed the burdens of toll payment, then a discount would not improve the absolute position of the least advantaged the most and should be replaced by the mode-based strategy from this perspective.

Deliberately targeted transportation improvement projects may also fair better under the egalitarian lens. If such strategies provide benefits specifically for those most vulnerable to the fee payment impacts, then the least advantaged may see their position improve greater than all others who would continue to pay the toll. In such a case it could be argued that the middle and upper-income commuters (who tend to drive more and make up a larger share of the commuting population) would be subsidizing mode choice accessibility improvements for the least advantaged and therefore would level the uneven playing field.

Finally, targeted mode choice improvement projects may also satisfy the requirements of the utilitarian lens (as well as enhance system effectiveness and efficiency), if they simultaneously provide for the saving of revenue by avoiding the enactment of a discount, and the benefits of decreased travel among those drivers who now have a choice and decide to opt for an alternative mode. Such a strategy would therefore provide for greater maximization of aggregate utility compared to the blanket discount strategy and would be the more appropriate choice from this perspective.

By analyzing these two mitigation strategies through a combined framework of egalitarian, utilitarian, and contractarian justice theories, it becomes evident that alternative mode strategies appropriately targeted toward the least advantaged have the potential to produce a more "just" situation than a blanket discount, while helping to protect the effectiveness and efficiency of the pricing program and system. Due to the highly spatial nature of such mitigation strategies, it is essential to identify the location of the effected population based on demographics, commute patterns, and alternative mode choice availability in order to appropriately target such population. Transportation investments that are inappropriately targeted may not only provide few benefits (if any) for the least advantaged, thereby failing to satisfy the requirements of the egalitarian and contractarian lens, but may also result in inefficiency, waste, and a loss in overall aggregate utility. These findings highlight how spatially-informed analysis is essential to such decision making, and can help transportation planners address issues of income, modal, and spatial equity while maintaining the effectiveness and efficiency of the cordon pricing system. Based on these findings, the following section presents the San Francisco case study for the spatially-informed contextual analysis presented in the remainder of this research. Though no specific policy recommendation are made, applying this conceptualization of equity in congestion pricing mitigation to the San Francisco case illustrates the importance of considering community-level impacts of pricing, particularly on those who are most disadvantaged.

Chapter 4

SAN FRANCISCO CASE STUDY

This chapter elaborates on the purpose and motivation behind the San Francisco Mobility, Access, and Pricing Study (MAPS), as well as examines the anticipated costs and benefits of such a program as determined by the study, and those strategies proposed to mitigate disproportionate impacts on disadvantaged groups.

San Francisco Mobility, Access, and Pricing Study (MAPS) Background

In 2007, MAPS was initiated by the San Francisco County Transportation Authority (SFCTA) to assess the feasibility of congestion pricing in San Francisco as part of a comprehensive strategy for travel demand management, alternative mode enhancement, and sustainable growth. With grant funding from the FHWA Value Pricing Pilot (VPP) program, the SFCTA examined available transportation performance data utilizing a travel demand model (SF-CHAMP) that simulates individual travel behavior to predict future travel conditions. The study determined that a San Francisco congestion pricing program would be both technically feasible and effective (SFCTA, 2010)

The potential design of the pricing system was a significant consideration in the San Francisco study. Scenarios examined (Figure 6) included a more limited downtown cordon, a gateway crossing fee combined with increased parking prices, gateway crossings with an additional downtown cordon fee, and a larger cordon surrounding the entire northeast corner of the city. The SFCTA concluded that weekday peak-period cordon pricing in the northeast portion of the city (bound by Laguna Street and 18th Street as illustrated in Figure 1) was the highest-performing feasible program, reducing demand and congestion while delivering substantial net revenues (SFCTA, 2010).

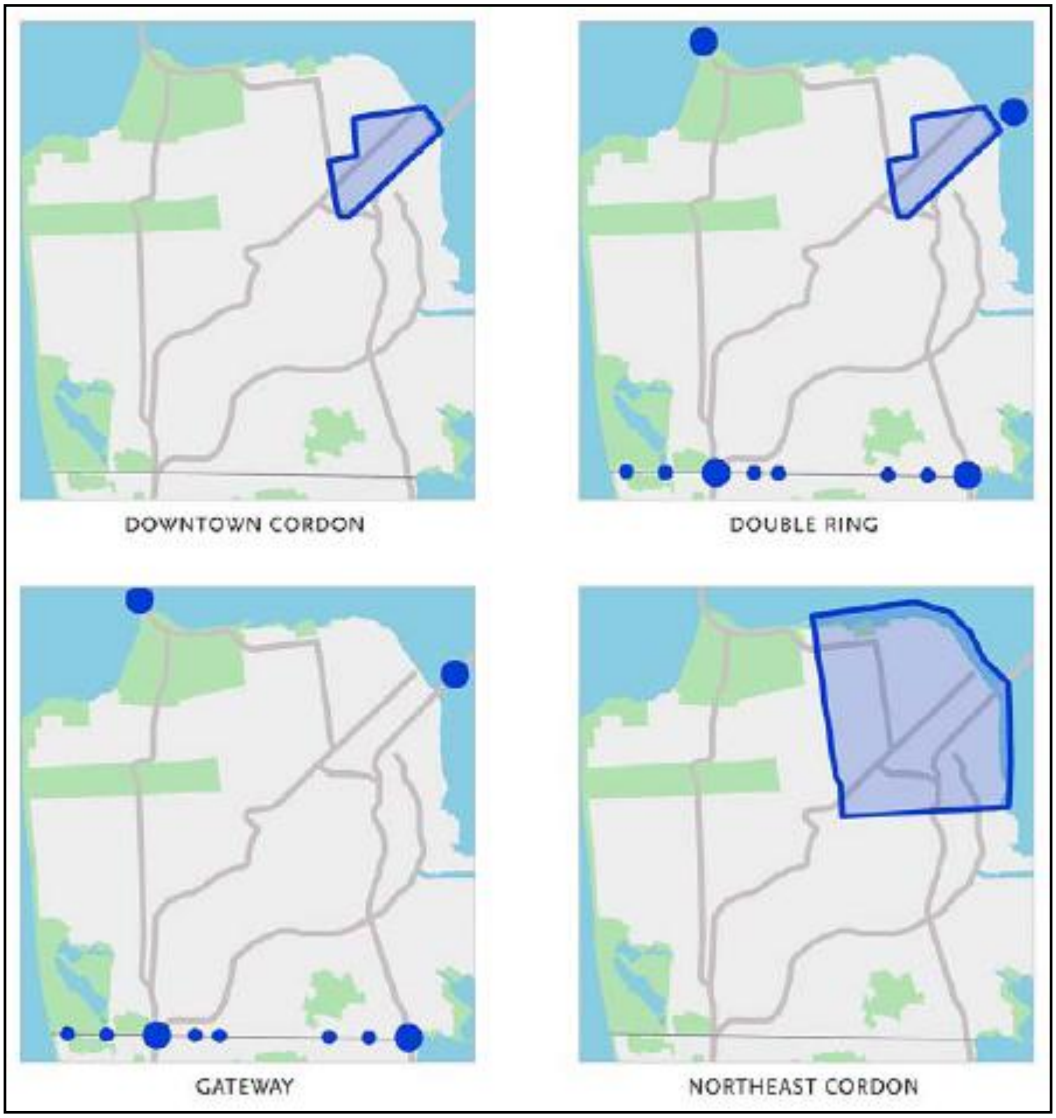

Figure 6. Initial MAPS program design options considered (SFCTA, 2010).

MAPS Costs and Benefits

The MAPS analysis determined that the proposed northeast cordon would generate $60 to 80 million in annual net revenue, which would be used to fund investments in the transportation system with particular emphasis on transit service enhancements focused on key corridors impacted by the cordon charge. These transit investments would be deployed prior to or in conjunction with the introduction of the congestion charge, in order to accommodate the forecasted 10 percent increase in peak-period transit mode share on trips taken to and from the cordon zone (SFCTA, 2010, p. 37).

In addition to potential revenue generation, the MAPS analysis determined that various non-financial benefits could also be obtained. Peak-period vehicle trips to and from the cordon zone are estimated to fall by more than 15 percent, decreasing daily citywide VMT by roughly five percent and a 13 percent decrease in vehicle delay hours during peak periods in the focus area (SFCTA, 2010, p 36). In addition, the study anticipates a reduction in vehicular collisions by six percent, as well as a five percent reduction in greenhouse gas and criteria air pollutant emissions citywide (SFCTA, 2010, p. 37). A cost-benefit analysis conducted during as part of the study determined that the program would produce net positive annual social benefits, with travel time savings to drivers and transit riders offsetting fee payment burdens. Though the results of the cost-benefit analysis appear to satisfy the criteria for utilitarian approval, they do not account for potential differential impacts on low-income automobile-dependent peak-period commuters in areas with poor accessibility to alternative modes. The benefits of travel time savings to these individuals may not offset the cost of fee-payment.

MAPS Mitigation Strategies

The MAPS proposal includes the consideration of various mitigation measures to reduce disproportionate impacts of cordon pricing. The study recommends consideration of a set of strategies, including exemption for transit vehicles and taxis, in addition to program discounts to address issues of geographic and income equity. These proposed discounts include a $1 fee-bate for bridge toll-payers, in addition to a 50 percent discount for residents living within the cordon zone, for disabled motorists, and for low-income drivers making less than $25,000 as defined by the region's "Lifeline" program (SFCTA, 2010). The study notes that the majority of peak-period motorist are from households with incomes greater than $100,000 per year, while less than five percent are from households with incomes less than $50,000 per year. In spite of the relatively low proportion of low-income drivers, MAPS recognizes that "there is a need to minimize the burden on low-income households through a discount measure" (SFCTA, 2010, p. 18). In addition, the report finds that, "Each discount affects the financial performance of a pricing program in that available gross revenues are reduced both in offering and administering the discount" (SFCTA, 2010, p. 18). Also noted is the conclusion that, "The low-income discount policy could be supplemented or replaced by a programmatic investment in a means-based transit fare assistance program" (SFCTA, 2010, p. 19).

These finding of the SFCTA appear to recognize that impacts of cordon pricing on low-income drivers warrants mitigation. Also, in spite of the relatively smaller proportion of such drivers impacted by the cordon toll, the report also recognizes potential impacts of discount strategies on system effectiveness (from a program standpoint at least).

The conclusions of the report and the proposed mitigation strategies, however, do not directly address the issue of disproportionate impacts of cordon pricing on low-income automobile-dependent peak-period commuters in areas with poor accessibility to alternative modes. Without considering such spatial-equity concerns, in addition to income and modal equity as conceptualized through a distribute justice framework, proposed methods for mitigating disproportionate impacts may not adequately address equity concerns, and may result in loss of cordon pricing program and system effectiveness and efficiency. Only through a community-level contextual analysis can the distribution of those most disadvantaged be identified, allowing for spatially-informed reinvestment of revenue in access-enhancing projects in these areas, and thereby helping to address equity concerns while maintaining the effectiveness and efficiency of the cordon system. The following section discusses the method utilized in this research to demonstrate the importance of including such contextual community-level equity analyses in transportation planning practice.

Chapter 5

RESEARCH METHODOLOGY

In this chapter, a method for examining the community-level impacts of cordon pricing is presented utilizing spatial and demographic analysis tools. The purpose of the method discussed here is to address the primary research question of this study, by demonstrating how a community-level spatial analysis of low-income automobile-dependent peak-period commuters in areas with poor access to alternative modes can help transportation planners better address spatial-based horizontal equity issues, as well as income-based and modal-based vertical equity issues from a distributive justice perspective, while still maintaining overall efficiency and effectiveness.

The modeling approach presented here consists of a top-level analysis for the identification of communities of concern, in which community impact assessments can be conducted in order to determine which context-specific access-enhancing mitigation strategies are appropriate. A method for determining commute patterns of workers impacted by cordon toll payment is discussed, utilizing data from the Longitudinal Employment and Household Dynamics (LEHD), while a method utilizing GIS to analyze the access of such workers to alternative modes of transportation is presented. This method is finally applied to the San Francisco case study.

Study Area

The Metropolitan Transportation Commission (MTC) acts as the metropolitan planning organization (MPO) for the nine counties that make up the San Francisco Bay Area (figure 7). These nine counties serve as the study area for this research, from which the location of San Francisco-bound commuters are determined. The area bound by Laguna

Street and 18th Street (figure 1) in the northeastern portion of San Francisco serves as the cordon zone of analysis, because it is the most likely scenario under consideration at the time of this research.

Figure 7. Bay Area counties in the study area (MTC, n.d.)

Modeling Approach

In order to analyze the impacts of cordon pricing toll payment on disadvantaged San Francisco commuters and identify appropriate study areas for potential revenue reinvestment, Geographic Information Systems (GIS) are utilized as the primary modeling tool. GIS was selected as the appropriate approach for addressing the research question for this project primarily due to the explicitly spatial nature of the research problem. This research attempts to understand where low-income San Francisco-bound commuters are located in relation to alternative transportation options, in order to analyze the spatial distribution of potentially vulnerable populations to the fee-payment impacts of cordon pricing. GIS is particularly useful for spatial data management and visualization and can be a powerful tool in policy analysis, therefore making it ideal for this research.

In recent years, an increasing number of researchers have incorporated GIS methods into their equity analysis of transportation policies and programs. For example, Fruin and Sriraj (2005) use GIS modeling to identify "environmental justice" neighborhoods and to assess the distribution of benefits from transit investments. Sanchez (1998) utilizes GIS to analyze the equity impacts of highway improvements on employment accessibility. Handy and Clifton (2001) use GIS to evaluate the accessibility of neighborhoods across an urban area and the equity of these accessibility patterns. The method presented in this research project has the potential to further contribute to the literature on GIS applications for equity analysis in transportation.

Though no specific policy recommendations are made in this dissertation, this initial top-level GIS analysis of potential communities of concern can be utilized to identify neighborhoods for future in-depth community impact assessments (CIAs) to supplement and inform the underlying data and determine whether revenue reinvestment is indeed an appropriate mitigation strategy. A CIA allows local residents to engage in problem solving and can generate a range of additional concerns, as well as solutions. Strategies identified through a CIA may be more acceptable for local residents, and may be overlooked by professional planners working from outside the culture of the community.

Public participation is a particularly important concern when dealing with issues effecting disadvantaged populations who typically have no voice in the planning process. As noted by Aimen and Morris (2012), effective public involvement in the decision-making process helps to improve the identification and understanding of traditionally underrepresented groups, is more inclusive by recognizing the needs of such populations, and is more comprehensive by allowing for better assessment of benefits and burdens of policies and plans across varying socioeconomic groups. The authors provide case studies that illustrate these benefits, such as the use of focus groups in Minnesota to examine the transportation needs and values of immigrant populations in the state. Though they note the associated cost of conducting such assessments, particularly the costs of researchers' wages and other administrative and overhead expenses, they highlight that the approach illuminated cultural differences that exist and that might be overlooked under conventional planning approaches, thereby avoiding further marginalization of a segment of the population in the decision-making process.

Other case studies found in the literature also illustrate the potential benefits of CIAs. In Calhoun Falls, South Carolina for example, a plan to widen State Route 72 included an effective CIA that provided benefits to both the public (through understanding of and support for transportation improvements and increased involvement of traditionally underrepresented groups) and to the agency (through the surfacing of crucial information on impacts and alternatives that better-informed the decision-making process) (FHWA, 2000). In Venice, Florida a CIA was conducted in preparation for the major reconstruction of heavily-traveled US Highway Business Route 41, allowing for the identification and resolution of safety issues unrecognized by the agency, as well as aesthetic improvements that enhanced the appeal of the project for community residents (CUTR, 2001). Finally, in Durham, North Carolina, residents opposed to a 10-mile limited-access highway were engaged in a CIA that resulted in the creation of a comprehensive mitigation and enhancement package that preserved community cohesion, while producing creative mitigation measures that would have been missed without such public involvement (FHWA, 2000). Although the tradeoff of time and administrative costs must be recognized, each of these case studies illustrate the potential ways in which CIAs can enhance the effectiveness and efficiency of transportation planning and decision-making.

Though a community impact assessment is an important final step in determining appropriate mitigation strategies, this research focuses primarily on two key components: providing a framework for the analysis of distributive justice implications of cordon pricing mitigation strategies, and providing a spatial analysis method for the identification of disadvantaged communities in which such strategies can be implemented. The determination of which specific form of mitigation should be initiated, based on the community-level context, is beyond the scope of this research, since appropriate decisions will vary from location to location. As such, the spatial analysis method presented here should be considered an initial step that better allows planners to target disadvantaged commuters, and in practice would be followed by a CIA of identified vulnerable populations.

Commute Pattern Analysis: Data Source and Method

The first objective of this case study analysis (Figure 8) is to determine the commute patterns and locations of disadvantaged San Francisco-bound commuters. In order to determine the location of these commuters within the Bay Area, data and GIS shapefiles were obtained from the Longitudinal Employment and Household Dynamics (LEHD) program website of the US Census Bureau. LEHD allows for dynamic web-based mapping of the relationship between where people live and where they work, by county, city, census tract or block. LEHD workplace locations are determined by utilizing Quarterly Census of

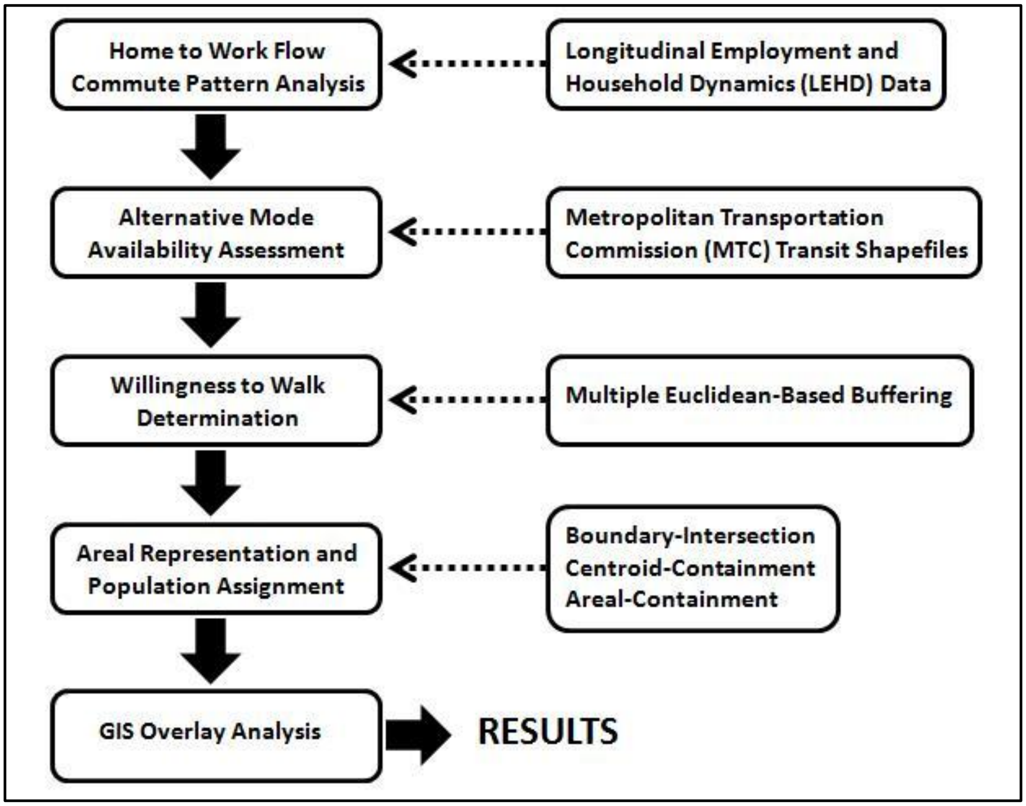

Figure 8. Research method and data sources.

Employment and Wage reports, supplemented with records from the Census Bureau's Business Register. This method takes into account all workers who are covered by unemployment insurance. As a result, self-employed, federal government workers, and those working in the "informal economy" sector are not accounted for. Residential addresses of workers are taken from the Statistical Administrative Research System (StARS), which combines several federal administrative files (Social Security, IRS, Medicare, Medicaid, Veteran's Affairs, etc.). Though the counts of workers and jobs in a specific block are "real" (with some added noise), the distributions between the residence block and the work block are synthesized to protect confidentiality.

LEHD data were utilized to produce home-to-work commute flows for residents of Bay Area working in the cordon pricing zone within the city of San Francisco. In addition, LEHD allows for the analysis of commute flows for workers making less than $1,250 per month, making it an effective tool for analyzing the location of low-income commuters.

Commuter Pattern Method: Strengths and Limitations

The use of LEHD data for the analysis of commute patterns offers several advantages over travel-model-based methods widely in use in transportation planning. First, it provides actual home to work locations for commuters at a finer scale, unlike travel models that use synthesized flows between transportation analysis zones (TAZs). While travel models have an apparent advantage of utilizing forecasted future year data, which is advantageous when analyzing large capital-intensive infrastructure projects (e.g. freeways, rail transit projects) that take many years to plan and build, cordon pricing strategies are less infrastructure-intensive and can be implemented in far less time. As such, the locations of communities of concern are less likely to change dramatically between planning and implementation of cordon pricing, therefore negating advantages of future forecasting. In addition, the accuracy of such complex forecasting travel models is often called into question, since such models require subjective assumptions and inputs. Though travel models have the other apparent advantage of being able to forecast the impacts of modal shift and forgone trips as a result of pricing increases, these advantages are limited by the fact that the target population for this research (i.e. commuters with no accessibility to alternative modes) has no other modal choices. In addition, as noted by Litman (2012) price elasticity of demand for work-bound trips tends to be far less than for other non-essential trips, thereby limiting the ability and willingness of the commuter to forego such necessary commutes.

In spite of the strengths offered by LEHD over travel-model-based methods for the analysis of commute patterns, there is one important limitation that must also be noted. LEHD does not account for departure time and only provides a spatial tool for analysis without temporal consideration. As such, those San Francisco-bound low-income commuters identified by such a method may be traveling during off-peak hours in which the cordon pricing would not be in effect. As such, these commuters would see no direct fee payment impacts from cordon pricing and would therefore be no further disadvantaged than their current position. This limitation of LEHD can be offset during initial stages of the community impact assessment process, at which point actual travel times can be analyzed by conducting surveys of residents.

Alternative Mode Accessibility Analysis Data Sources

The next step in this research involves an analysis of alternative mode accessibility for Bay Area residents. To accomplish this task, various considerations of accessibility have to be accounted for and different data are needed. GIS shapefiles acquired from the Bay Area Metropolitan Transportation Commission (MTC) website, including transit routes and stop locations, were utilized to determine accessibility to direct and indirect trans-bay transit service options. Direct rail-based options included in this analysis consisted of Bay Area Rapid Transit (BART) routes, while other direct options included ferry services provided from several locations, and trans-bay bus service provided by AC Transbay, WestCAT, samTrans, and GGT Transbay, in addition to Muni bus service for San Francisco residents bound for the downtown pricing zone. In addition to these direct transit options, indirect options included local bus services providing connections to these trans-bay options.

Willingness-to-Walk Distance Determination

How far a commuter is willing to walk in order to access a transit stop is an important yet debatable consideration. According to research by Untermann (1984), willingness to walk to transit stations varies by distance, with most people comfortable with walking 500 feet, 40 percent willing to walk 1000 feet, and only 10 percent content with a half-mile (2640 feet) access distance. Ewing (1999) determined that those pedestrians walking less than 2000 feet constituted 80 percent of cumulative pedestrians arriving at transit stations. As Canepa (2007) notes, a half-mile (ten minute) radius surrounding rail stations and a quarter-mile (five minute) radius for bus stops has become the generally accepted standard for maximum walking distances in the urban planning profession. Canepa argues, however, that the distance of pedestrian willingness to walk may actually fluctuate in size, as more recent studies have indicated. He notes the impacts of employment and housing density, aesthetically pleasing design and street connectivity on willingness, as well as pedestrian level of service (LOS). Alshalalfah and Shalaby (2007) reached similar conclusions in their study of Toronto, finding that people were willing to walk farther than existing standards assume. Weinstein Agrawal, Schlossberg, and Irvin's (2008) survey of 328 pedestrians accessing rail stations, found that more than half of respondents walked at least a half-mile, further demonstrating that commonly held assumptions of walking distance may be understated. They also found that those surveyed rarely mentioned aesthetics of the built environment as an important factor when selecting a route, and instead mentioned distance-minimization and safety as more important factors.

As with other similar recent studies recognizing the fluidity and context-specificity of transit access distance, Guerra, Cervero, and Tischler's (2011) station-level direct demand model for estimating transit ridership uses multiple transit catchment bands or buffers surrounding transit stations. The research of Bay Area transit access presented here takes a similar methodological approach, utilizing two quarter-mile catchment buffer bands around all direct trans-bay bus options and half-mile and three-quarter-mile buffers around trans-bay rail and ferry stations.

The use of multiple buffer bands allows for the designation of different degrees of accessibility, as opposed to an all-or-nothing approach of determining accessibility utilizing a (somewhat arbitrary and perhaps questionable) single buffer. A multi-buffer approach such as this, also allows planners to better assess not only the equity implications of accessibility, but also the balance between equity goals and the effectiveness and efficiency of the pricing strategy. If the smaller traditional half-mile buffer is analyzed alone, then the number of disadvantaged commuters in need of mitigation will appear greater than under a larger buffer. If revenue were to be reinvested in projects across all of the identified "inaccessible" areas outside the half-mile buffer, this could limit the ability to utilize the revenue more efficiently and to effectively address equity issues. Utilizing a larger buffer could arguably allow for a more efficient investment of revenue to address equity concerns, however, if the larger buffer fails to account for disadvantaged commuters located within this band yet inaccessible due to contextual issues, then the extended buffer may understate the equity concerns. Multiple buffering allows planners to better analyze these tradeoffs of efficiency and effectiveness when attempting to mitigate equity concerns.

The use of Euclidian-distance buffers to determine accessibility to transit modes has its limitations, because it assumes that travel can be completed "as the crow flies" and does not consider barriers that get in the way. It is arguable that a more accurate approach might be a full network analysis that considers not only the actual network-based (rather than Euclidian) distances as buffers, but also examines all physical barriers, as well as psychological and symbolic barriers, in addition to the condition and design of the pedestrian and bicycle environments for all potential paths. Such an approach would be extremely laborious and limit its usefulness from a practical application standpoint for a full analysis of all Bay Area commuters and their accessibility to alternative modes. As Guerra et al. (2011) note, calculating network-based distance buffers adds significantly to data collection efforts, yet “provide little to no benefit in terms of predictive power” (p. 4) when analyzing transit catchment areas. They point out that road network files do not consider more direct pedestrian access provided by parking lots, parks, and other paths surrounding transit stations. In their analysis of accessibility to public parks, Boone et al. (2009) also note that network analysis “discounts the cut-throughs and informal paths that walkers use to straighten their paths to destinations” (p. 6). Weinstein Agrawal et al. (2008) found that minimizing walking distance was the most influential factor on route choice to rail transit stations among those surveyed. These finding further illustrates how pedestrians will create their own path where possible by deviating from the network to minimize walking distance, thereby further limiting the usefulness of more laborious network-based approaches. In addition, the uncertainty surrounding willingness-to-walk distances makes such “precise” methods for determining transit catchment areas seem unnecessary, particularly for the top-level analysis conducted in this research. Due to these limitations, the Euclidian-distance method was utilized in place of these methods. Sensitivity analysis was also conducted, however, to highlight potential variances between Euclidean-based and network-based approaches.

The option of using local bus service to connect to direct trans-bay transit service is another choice that must be considered for San Francisco commuters. As such, quarter-mile buffers (the traditional standard within the planning profession as previously discussed) were utilized around local bus stops providing connections to trans-bay service. The need for transfers, however, can significantly reduce the attractiveness or feasibility of this option. As such, those commuters located within these local bus buffers are considered as having "limited" accessibility to alternative transport modes as opposed to the "direct" access provided by trans-bay services

Areal Representation Units and Population Assignment

Utilizing these estimated distances as buffers around Bay Area transit stops, the final step was to determine the appropriate areal representation units and populations assignment methods. As noted by Higgs and Langford (2009), environmental justice research has focused more heavily on considerations of buffer size importance, while less research has examined the methods by which the spatial distributions of populations are modeled. The most precise method, in the case of this particular research, would be to analyze the demographics of all land parcels containing San Francisco-bound commuters that fall outside of the transit-accessible buffer zone surrounding transit stations. Due to the lack of data available from LEHD at such a fine scale, aggregations of households into larger units (i.e. census blocks) are necessary. The use of aggregated spatial data, however, presents certain challenges when attempting to determine the demographics of impacted populations utilizing GIS, particularly the commonly recognized Modifiable Area Unit Problem (MAUP) illustrated in Figure 9.

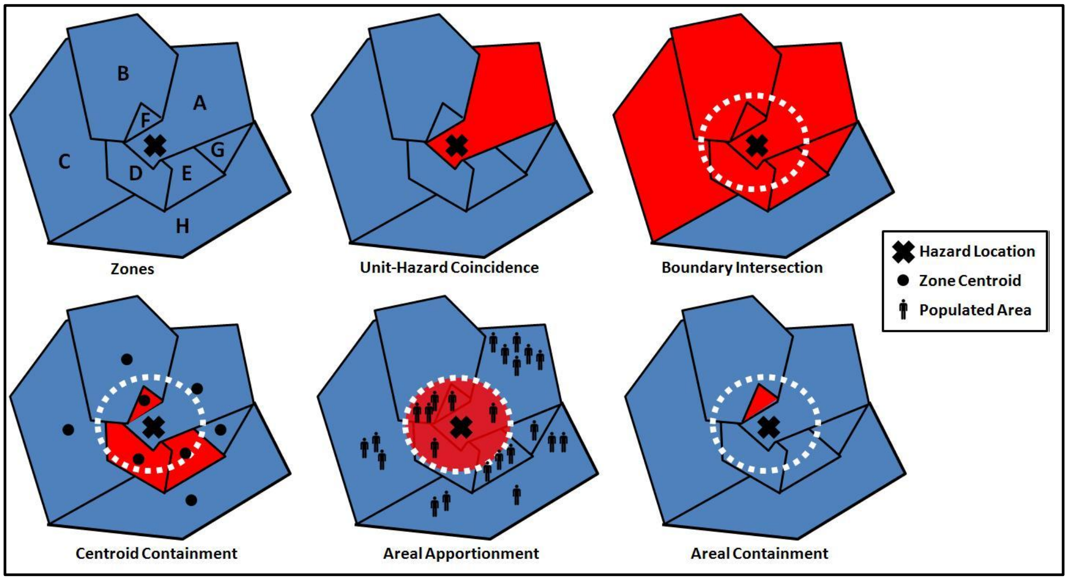

Figure 9. Examples of the Modifiable Area Unit Problem (MAUP).

Mohai and Saha (2006) note that traditional environmental justice research examining the distribution of populations impacted by locally unwanted land uses (LULUs) and environmental hazards tend to utilize the approach they refer to as unit-hazard coincidence, which can easily fall prey to the MAUP. Under such an approach, the demographics of those predefined geographic units (e.g. census tracts, counties, etc.) containing a hazard are compared with those that do not contain a hazard. In place of hazards, the location of environmental benefits (such as transit stations) could also be analyzed in a similar fashion. The significant weakness of such an approach, as noted by the authors, is that it does not account for the exact location of hazards within each geographic unit, nor does it recognize the proximity of hazards to other surrounding units nearby (e.g. Zones D, E, F, and G in Figure 9) and thereby assumes that those within the host unit are inherently closer to the hazard. In addition, if a host unit is very large (e.g. Zone A), only a small portion of the population may actually live near the hazard itself, as opposed to a small host unit where proximity may be better assured.

In response to these weaknesses, alternative distance-based methods have been proposed to enhance accuracy. The weakest of these approaches, according to Mohai and Saha (2006), is the boundary intersection method, in which units whose boundaries are contained within, intersected by, or tangent to a pre-defined hazard buffer are considered impacted. As a result, such methods may still assume that units with substantial area well beyond the buffer are impacted (e.g. Zones A, B, C, E, and G in Figure 9) and thereby share the similar shortcomings of the unit-hazard coincident approaches.

Under a potentially more accurate method, those units where at least half of the area falls within the hazard buffer are considered impacted, while those units with less than 50 percent falling within the buffer are consider non-impacted. An alternative strategy, the centroid-containment method, considers those units whose geographic center falls within the hazard buffer as impacted, and compares the averaged demographics against those units whose centroid falls outside the buffer. Either strategy helps to reduce the problem of overestimating impacted populations by reducing the chance that only marginally impacted units are included in aggregate totals (e.g. Zones C and G in Figure 9), as could be the case with the boundary intersection method. These strategies also help avoid the problem of underestimating impacts that plagues unit-hazard coincidence methods, by ensuring that non-host units closely neighboring facilities are more likely to be included (e.g. Zones D, E, and F). The weakness of either strategy, however, is that the entire population of a unit is still assigned either completely or not at all (e.g. Zone A)

Another strategy, the areal apportionment method, determines impacts by weighting the population of each impacted unit based on the proportion of the area of the unit that fall within the buffer. This approach helps to avoid the "all or nothing" assignment that befuddles the previous methods discussed, in which the entire population of a unit is designated as impacted or not. The areal apportionment method does have one weakness, in that it assumes an even distribution of a population (and its characteristics) across the entire unit. This may result in over-estimated impacts (e.g. Zones A and E in Figure 9), or under-estimated impacts (e.g. Zone B). Mohai and Saha (2006) note, however, that such an assumed uniformity within census units is implicit in census data research generally.

Higgs and Langford (2009) seem to agree with this finding, noting that in many cases ancillary information that would allow for further micro-scale analysis is simply not available. When such data are available, as the authors point out, dasymetric techniques can be utilized. Such strategies utilize additional information to differentiate populated space from unpopulated space, and then distribute the unit headcount evenly across the space deemed as populated. This approach can be particularly useful in rural areas where census units may be quite large and contain stretches of unpopulated land. As Boone (2007) demonstrates, dasymetric techniques can also be useful in suburban and urban areas with mixed land uses. Though dasymetric techniques can potentially improve the accuracy of results, such methods are not undertaken in this top-level spatial analysis.

In order to test the impacts of population assignment methods on overall results, in this research three different strategies are examined. In the first strategy, the boundary intersection method is utilized, where units whose boundaries were contained within, intersected by, or tangent to, a buffer were given that accessibility rating. The second strategy utilized is the centroid-containment method, in which a unit whose centroid is contained within a buffer is given that designation. Finally, the areal apportionment method serves as the basis for the third strategy, with impacted population deemed proportional to the amount of land area impacted. For illustrative purposes and to further test the sensitivity of areal representation selection to the MAUP, an even more restrictive method of total areal-containment was also employed, in which only blocks falling completely within the area of the buffer were considered accessible.

Following the method as described, an analysis of the San Francisco situation reveals the differential and highly spatial impacts of cordon pricing on disadvantaged commuters that illustrate the need for community-level contextual analysis in order to address cording pricing equity concerns. The next section discusses the results of the data analysis and identifies communities of concern for further examination and potential mitigation efforts.

Chapter 6

DATA ANALYSES AND RESULTS

The results of the San Francisco case study discussed below demonstrate how a community-level spatial analysis of low-income automobile-dependent peak-period commuters in areas with poor access to alternative modes can help transportation planners better address spatial-based horizontal equity issues, as well as income-based and modal-based vertical equity issues from a distributive justice perspective, while still maintaining overall efficiency and effectiveness. The geographic distribution of low-income San Francisco-bound commuters identified by the LEHD data analysis, combined with the spatially-influenced availability of alternative transportation access for these disadvantaged drivers, illustrates the pressing need for such contextual analysis and the identification of communities of concern for further community impact assessment in order to allow for spatially-informed reinvestment of revenue in access-enhancing projects in these areas.

The following section discusses the results of the data analysis from the San Francisco case study, highlighting the spatial distribution of those disadvantaged commuters potentially impacted by the proposed cordon system, as well as the availability of transportation alternatives to these effected Bay Area residents. Sensitivity analysis that examines the impact of areal representation units, assumptions regarding willingness-to-walk distances, and Euclidean-based versus network-based accessibility approaches is discussed. Finally, based on the results of the analysis, potential communities of concern with large concentrations of disadvantaged San Francisco-bound commuters are identified in the Bay Area.

San Francisco-Bound Commuters

Utilizing the data from LEHD, the location of low-income commuters within the San Francisco Bay Area was first determined. Of the 334,315 commuters identified by LEHD who make the trip to the cordon zone, 51,980 of those commuters (or 15.5%) earn an income of less than $1250 per month (Figure 10). These low-income commuters serve as the target group of this analysis, for which accessibility to transit alternatives was determined.

Figure 10. Inflow and outflow of low-income cordon zone commuters.

Figure 11 illustrates the general spatial distribution of these commuters across the entire study area, demonstrating that low-income residents of all areas of the bay make the work commute to downtown San Francisco. A closer analysis by area highlights those locations with a large concentration of low-income commuters traveling to the proposed cordon zone. As can be seen in the maps in Figures 11-16, in addition to the high concentration of low-income workers who live within the pricing zone itself, other areas where such commuters tend to reside in large number include the eastern bay-side communities from San Pablo and Richmond south through Oakland and into San Leadro and Hayward. Inland areas of Contra Costa and Alameda counties also contain a fair share of low-income commuters, including the Concord-Pleasant Hill-Walnut Creek area. South of San Francisco, in San Mateo county numerous commuters are concentrated from Daly City south through Millbrae and Foster City, while Santa Clara county in the South Bay contains scattered concentrations throughout. Finally in the North Bay, commuters are spread moderately from Sausalito north to Novato, while smaller pockets are found in the communities in southern Napa and Solano counties.

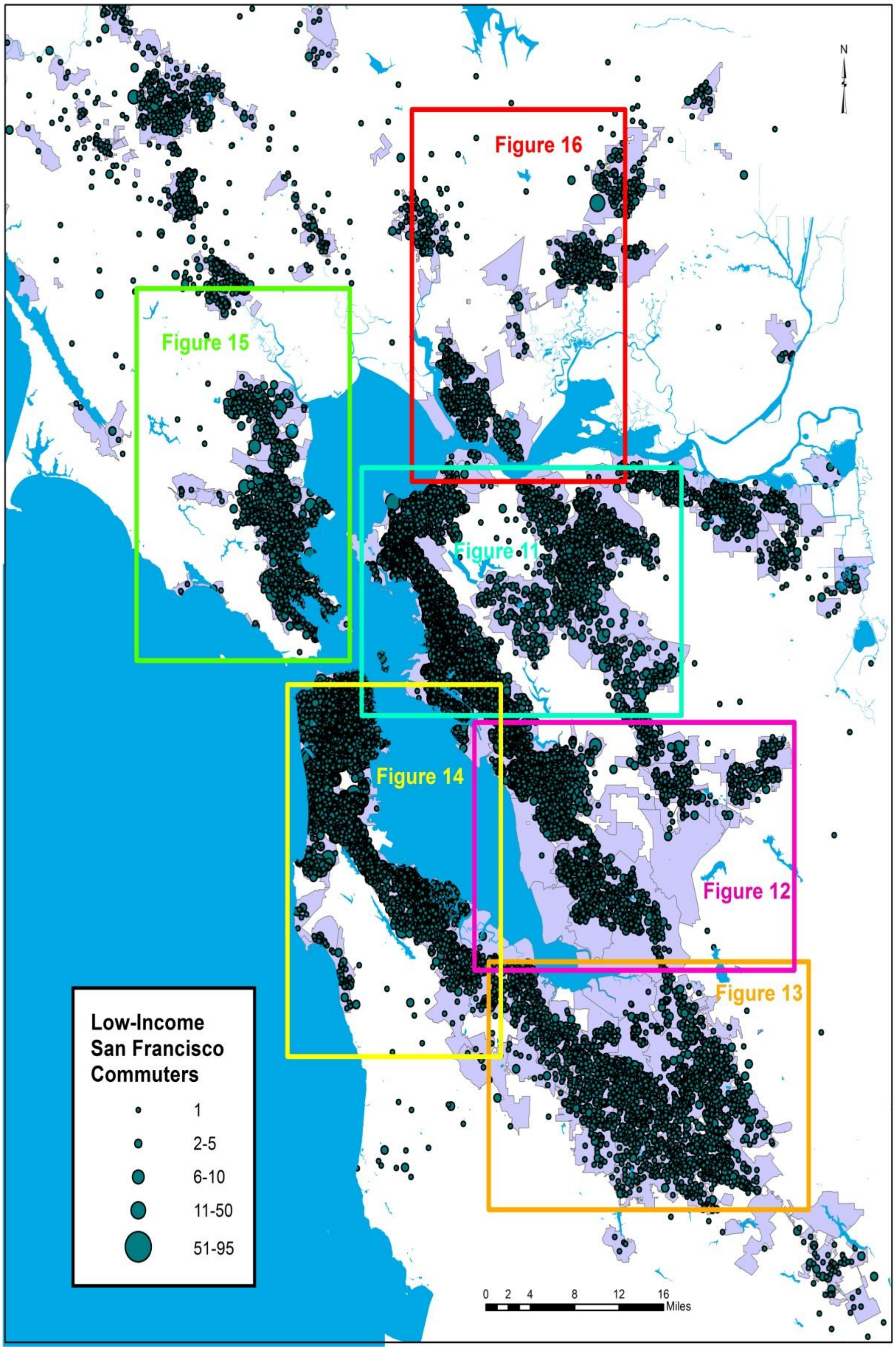

Figure 11. Location of low income San Francisco-bound commuters.

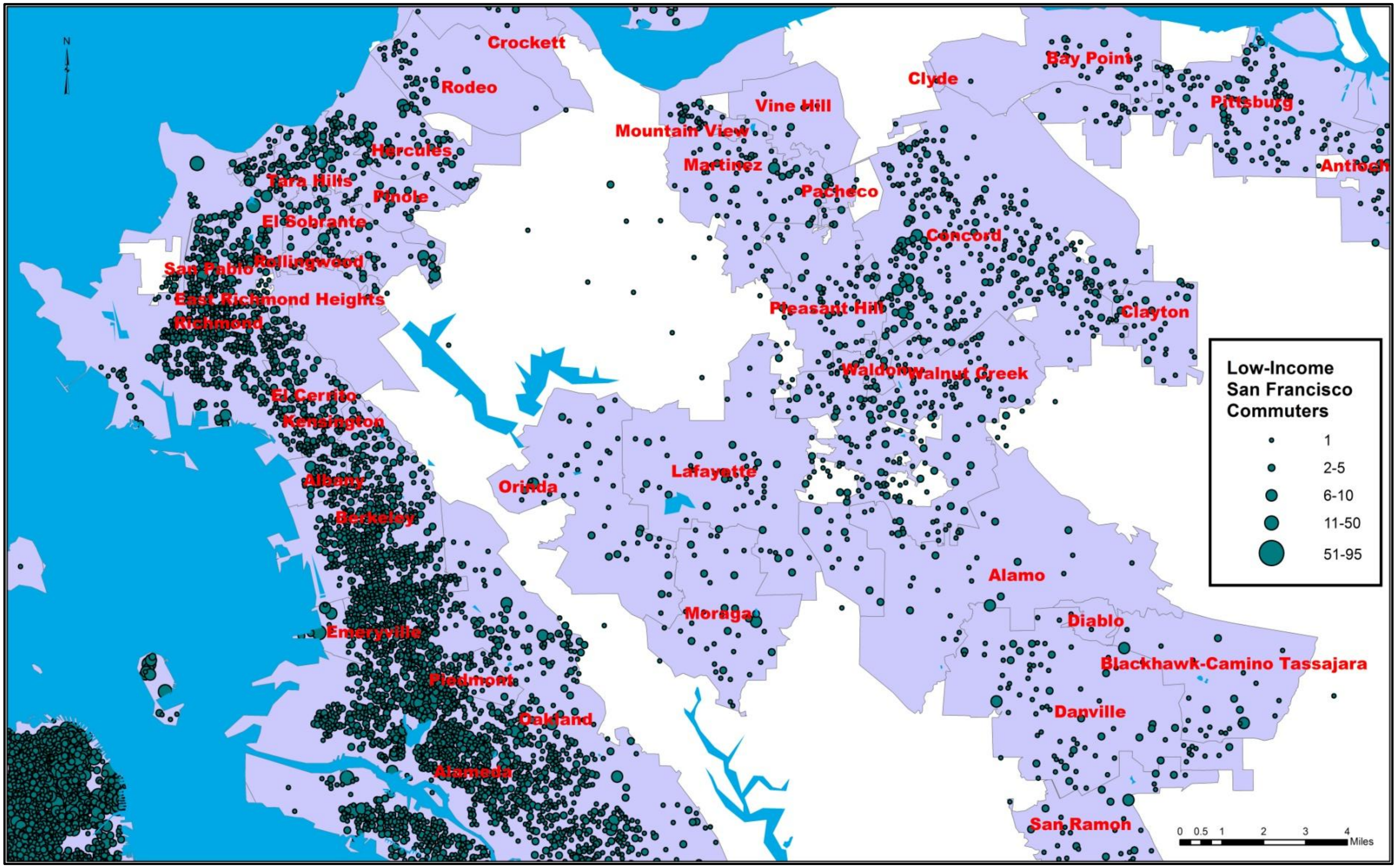

Figure 12. East Bay Area low-income commuters.

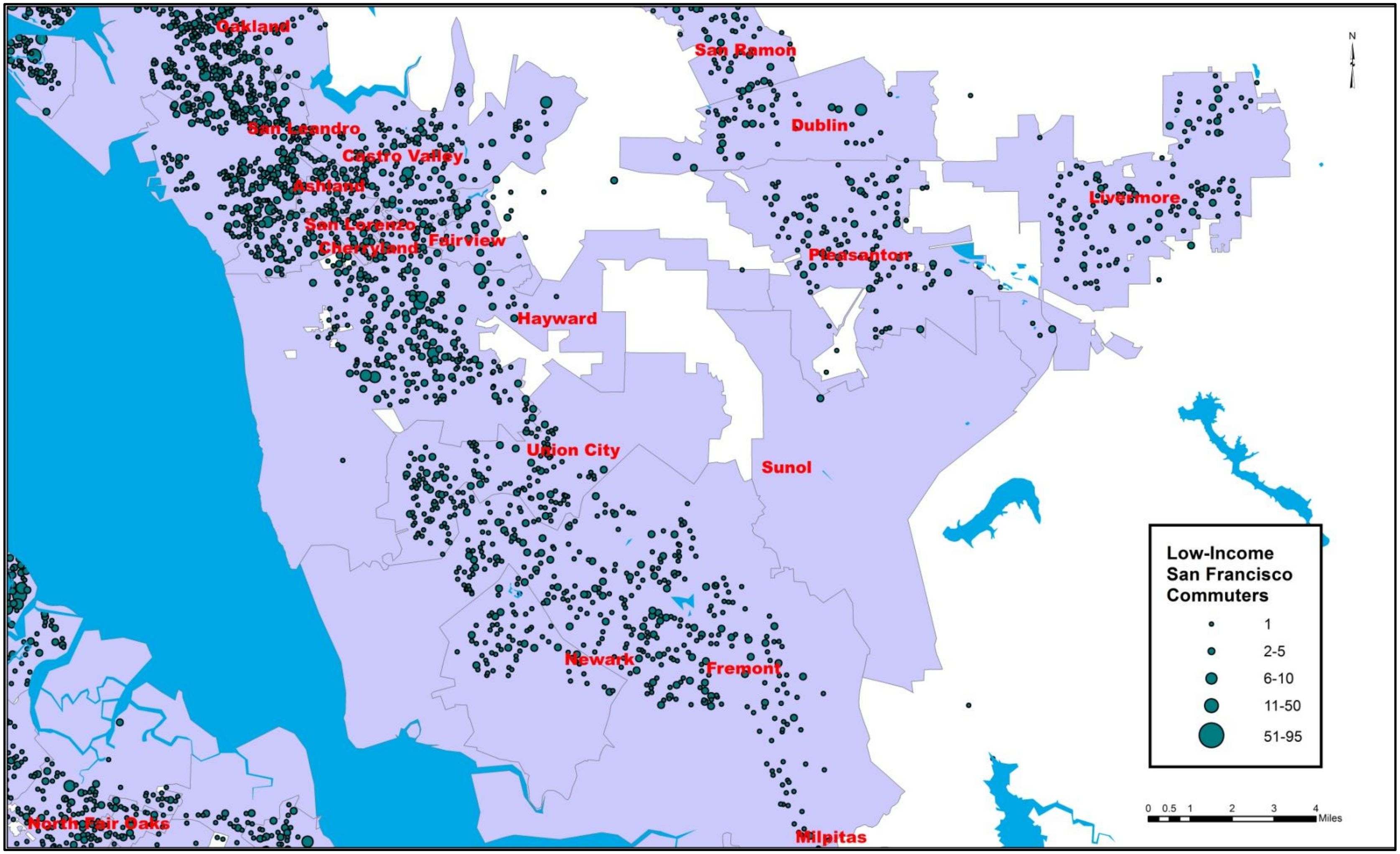

Figure 13. Southeast Bay Area low-income commuters.

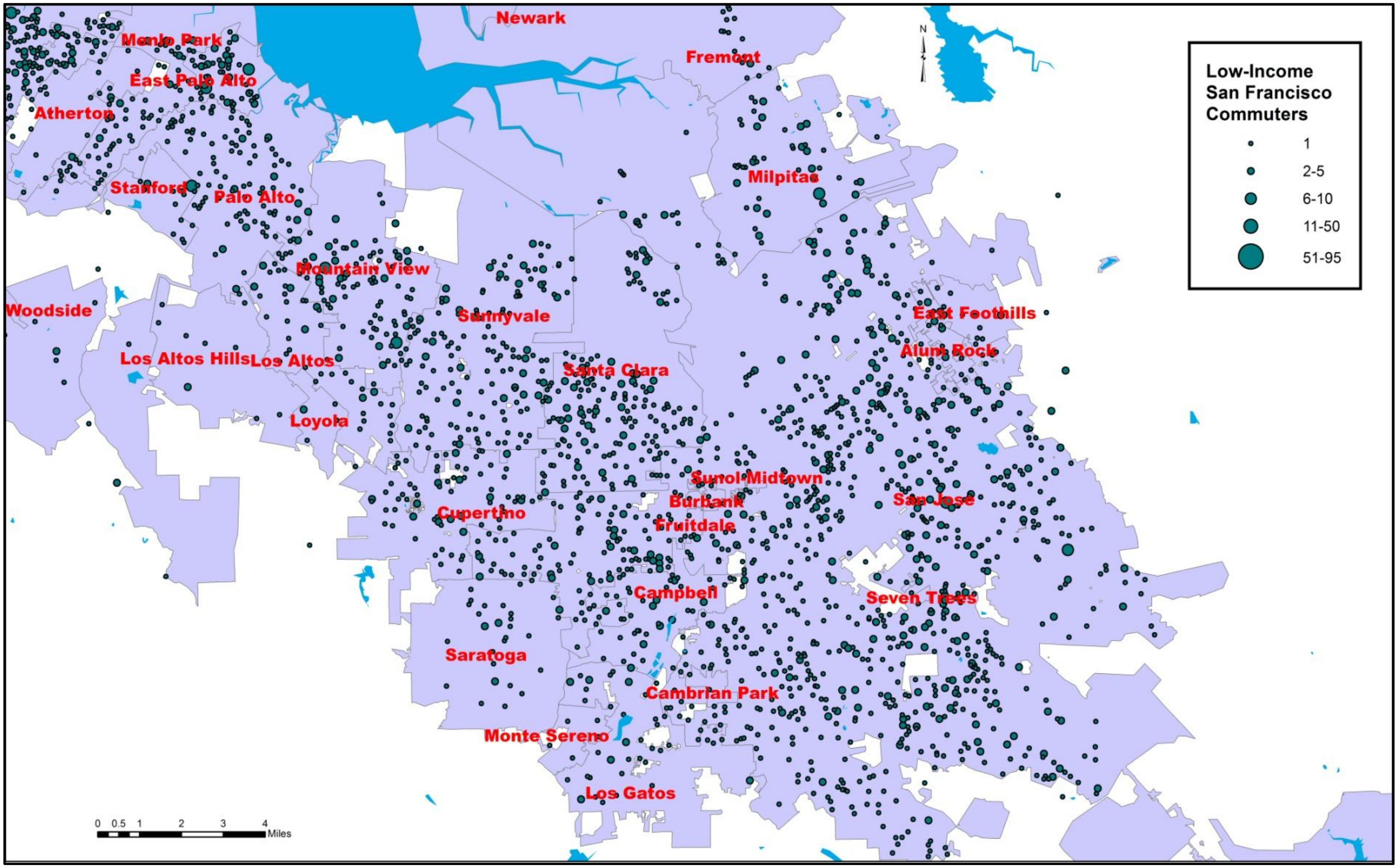

Figure 14. South Bay Area low-income commuters.

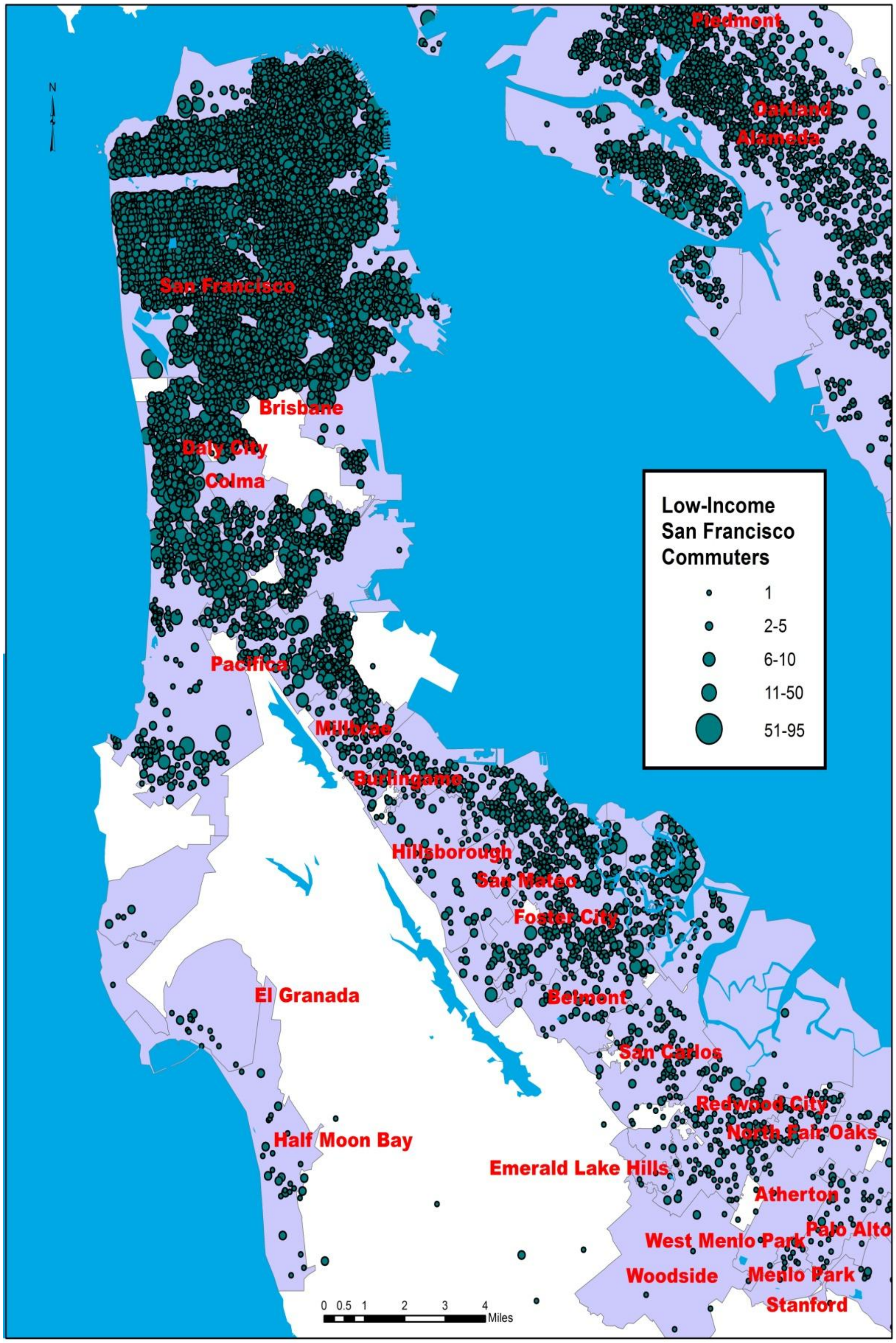

Figure 15. Southwest Bay Area low-income commuters

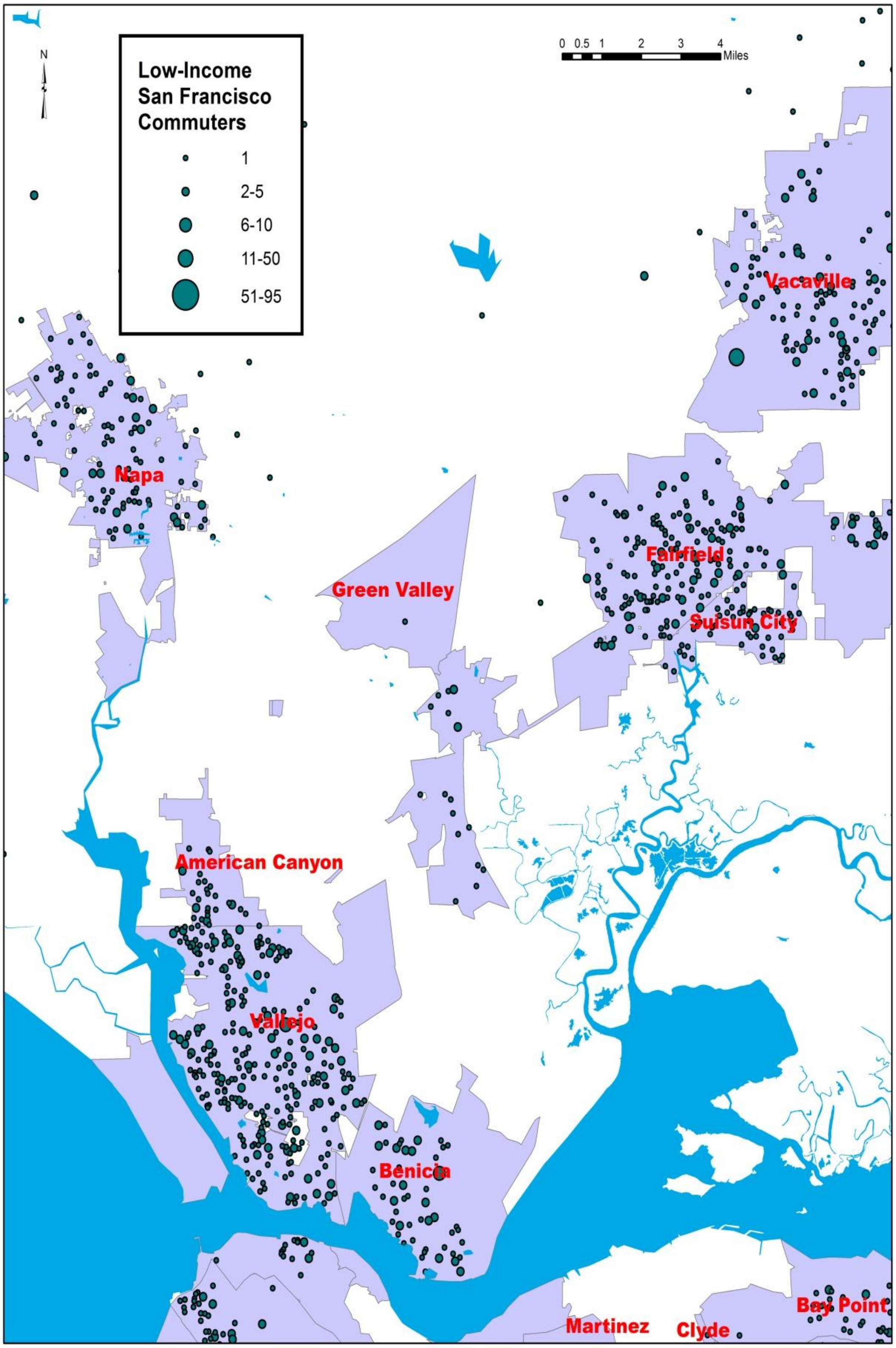

Figure 16. Northeast Bay Area low-income commuters.

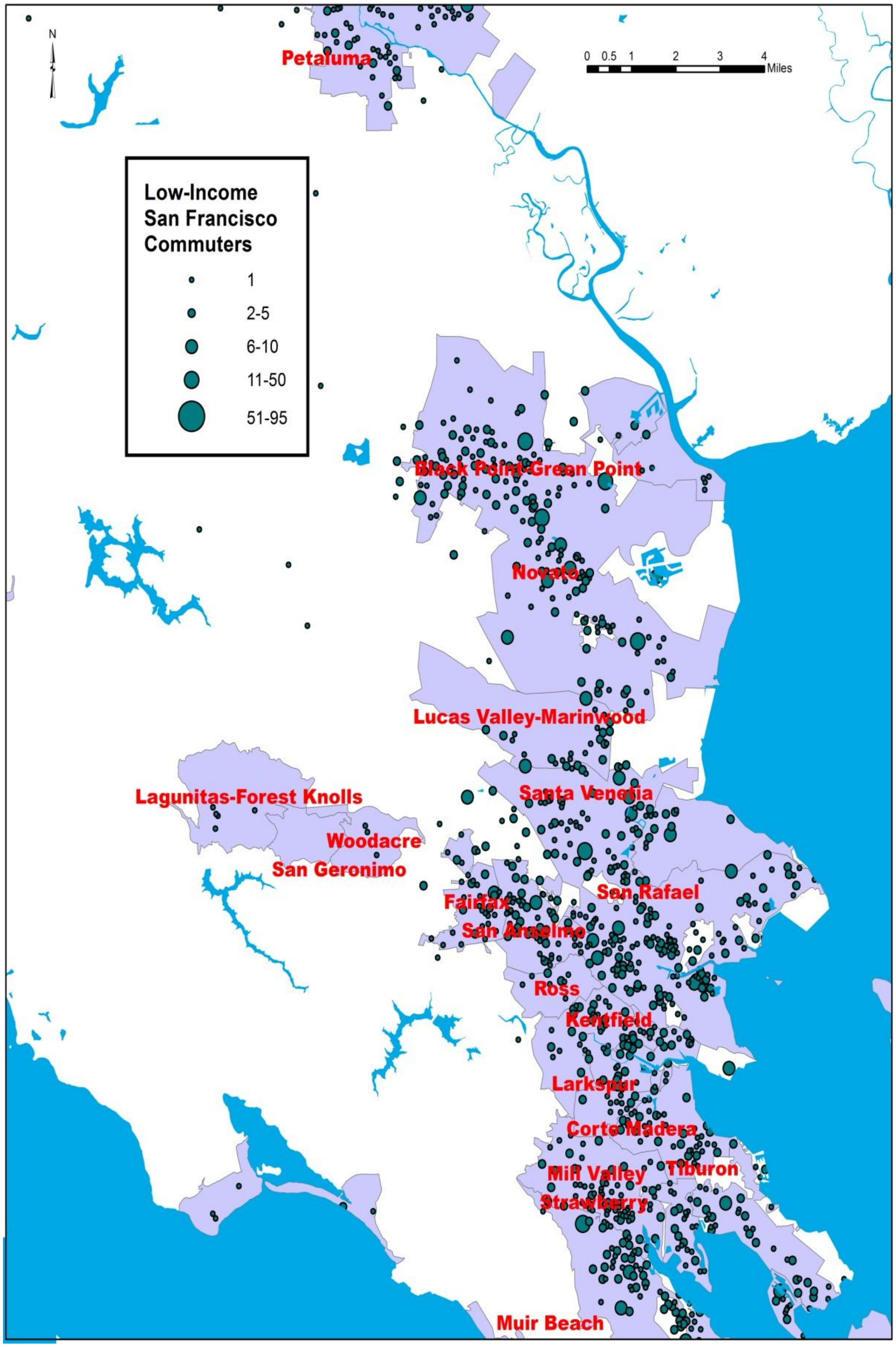

Figure 17. Northwest Bay Area low-income commuters.

Alternative Mode Accessibility Results

With the concentrations of low-income San Francisco-bound commuters identified at the census block level, the accessibility of these blocks to alternative transport modes was analyzed. Figures 18 and 19 illustrate the Bay Area-wide distribution of transit accessible blocks, as determined by the methods of boundary intersection, centroid containment, and areal apportionment (in this case, complete areal containment). Figure 18 considers access to all direct San Francisco-bound services with extended buffers, including rail (three-quarter-mile buffers), trans-bay bus and ferry (half-mile buffers). These services are primarily concentrated in Alameda and San Mateo counties, with Contra Costa County accessible only via rail, Marin County via bus and ferry, and Sonoma County by bus only. Figure 19 utilizes the same buffers for direct service, but also includes indirect access via local bus (utilizing quarter-mile buffers) and the SCVTA light rail (with half-mile buffers).

A closer examination of the use of extended buffering, which goes beyond the conventionally accepted half-mile rail and quarter-mile bus distances, demonstrates how buffer selection can have significant impacts on accessibility designation. In Figure 20, East Bay BART station accessibility was first determined utilizing the conventional half-mile approach. By comparison, in Figure 21 an extended three-quarter-mile buffer was used, significantly increasing the coverage area of the BART stations and the blocks considered accessible.

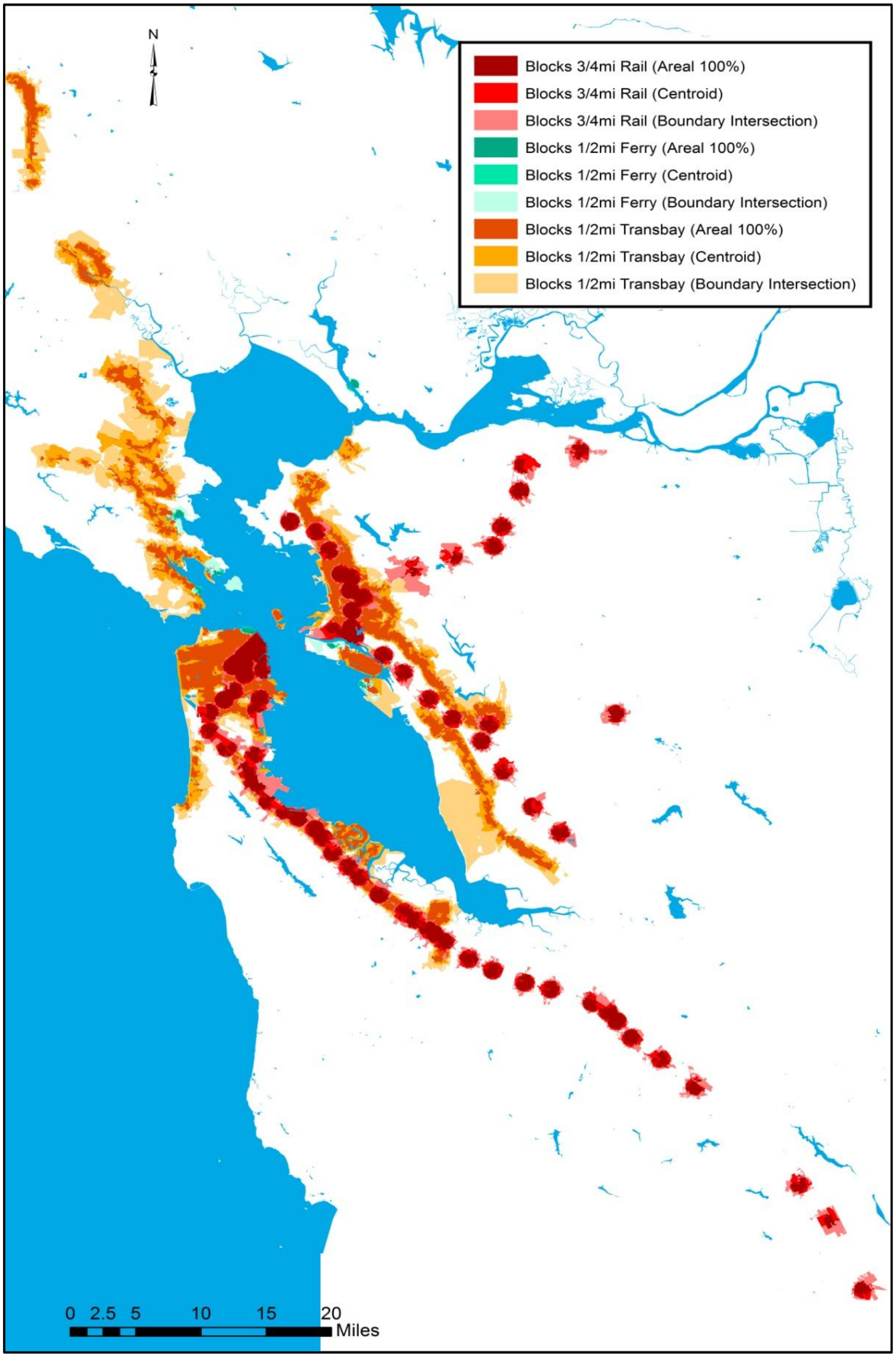

Figure 18. Bay-wide direct trans-bay accessible census blocks.

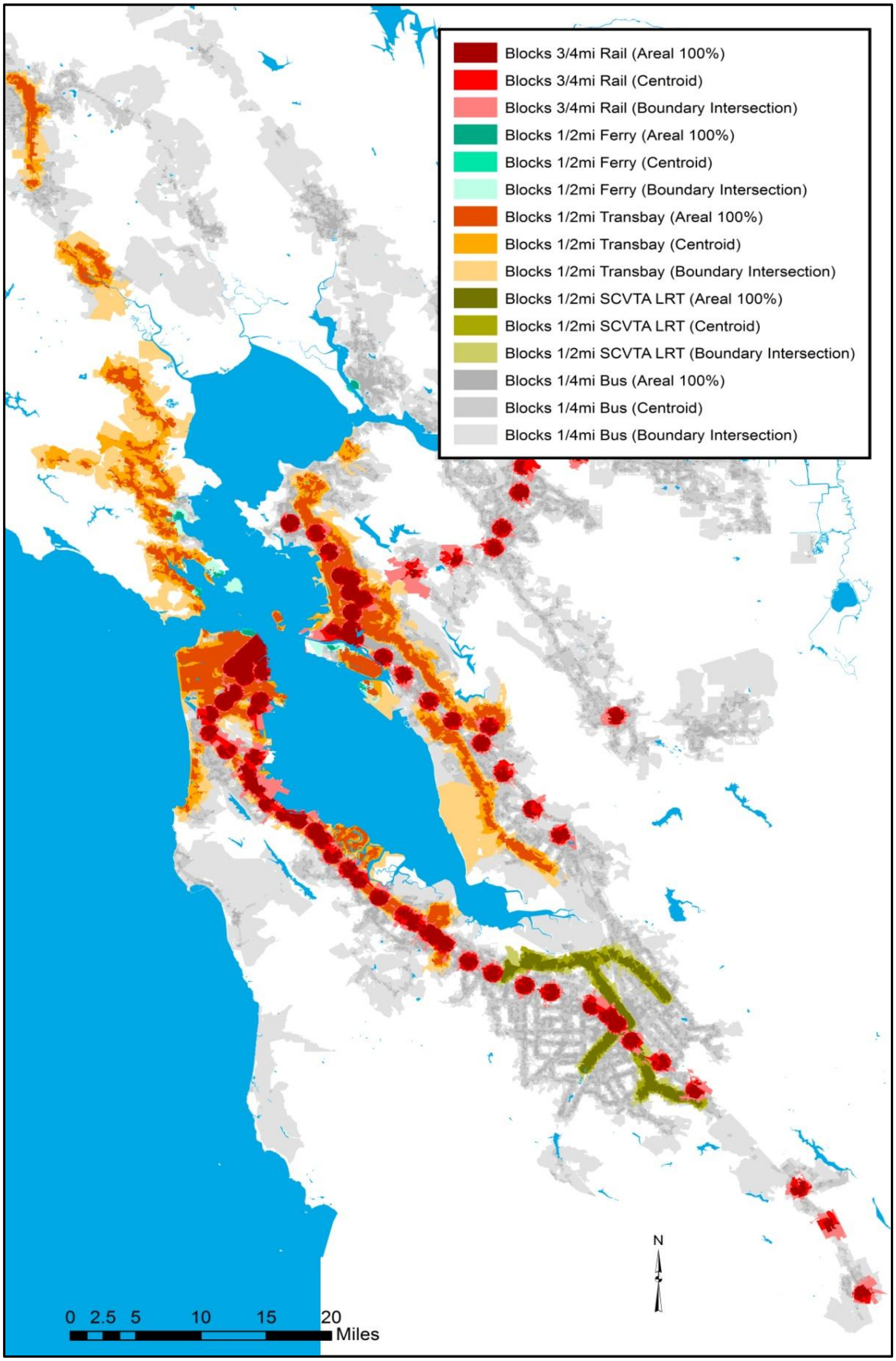

Figure 19. Bay-wide direct and indirect trans-bay accessible census blocks.

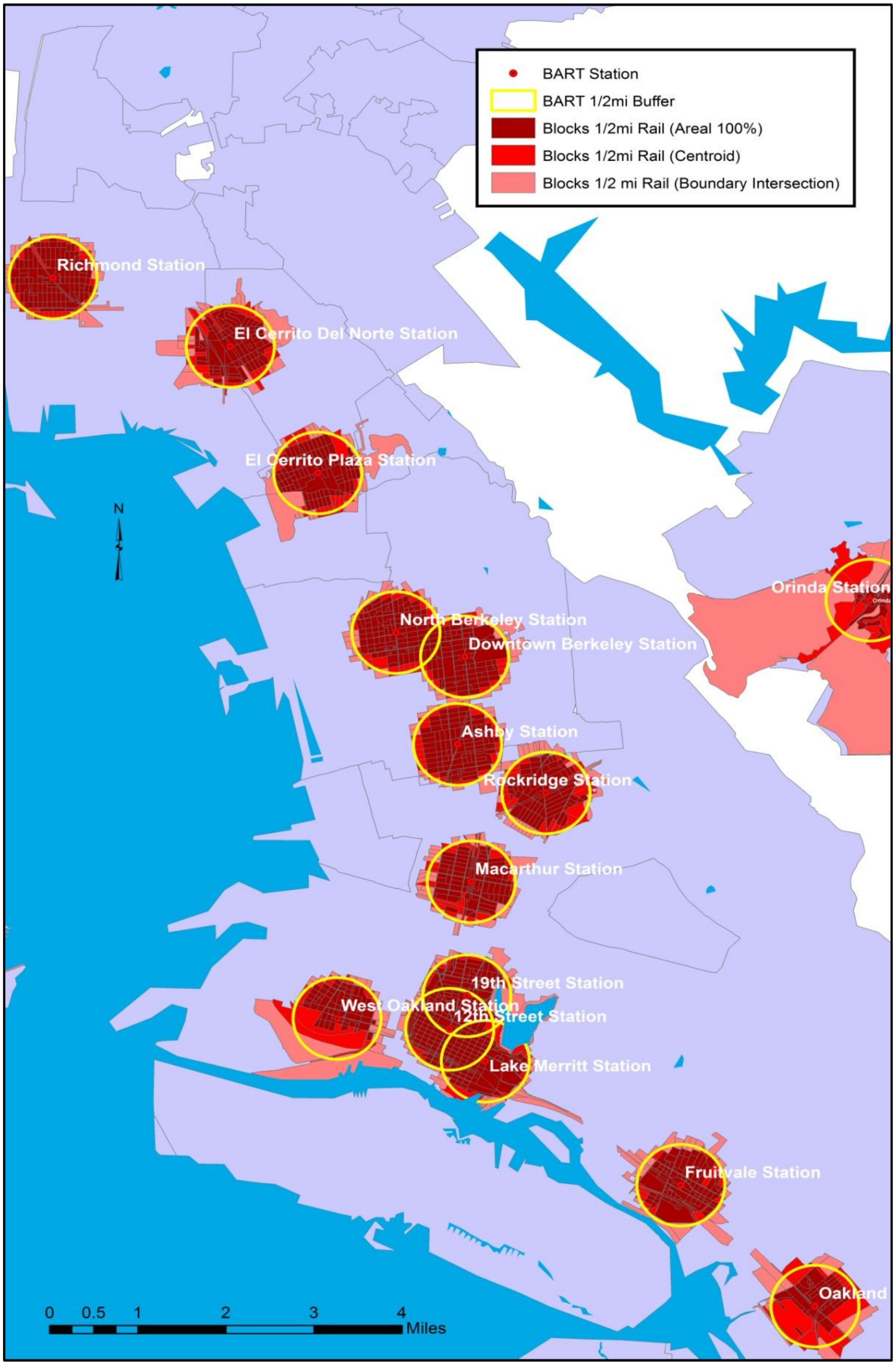

Figure 20. BART accessible blocks utilizing half-mile rail buffer.

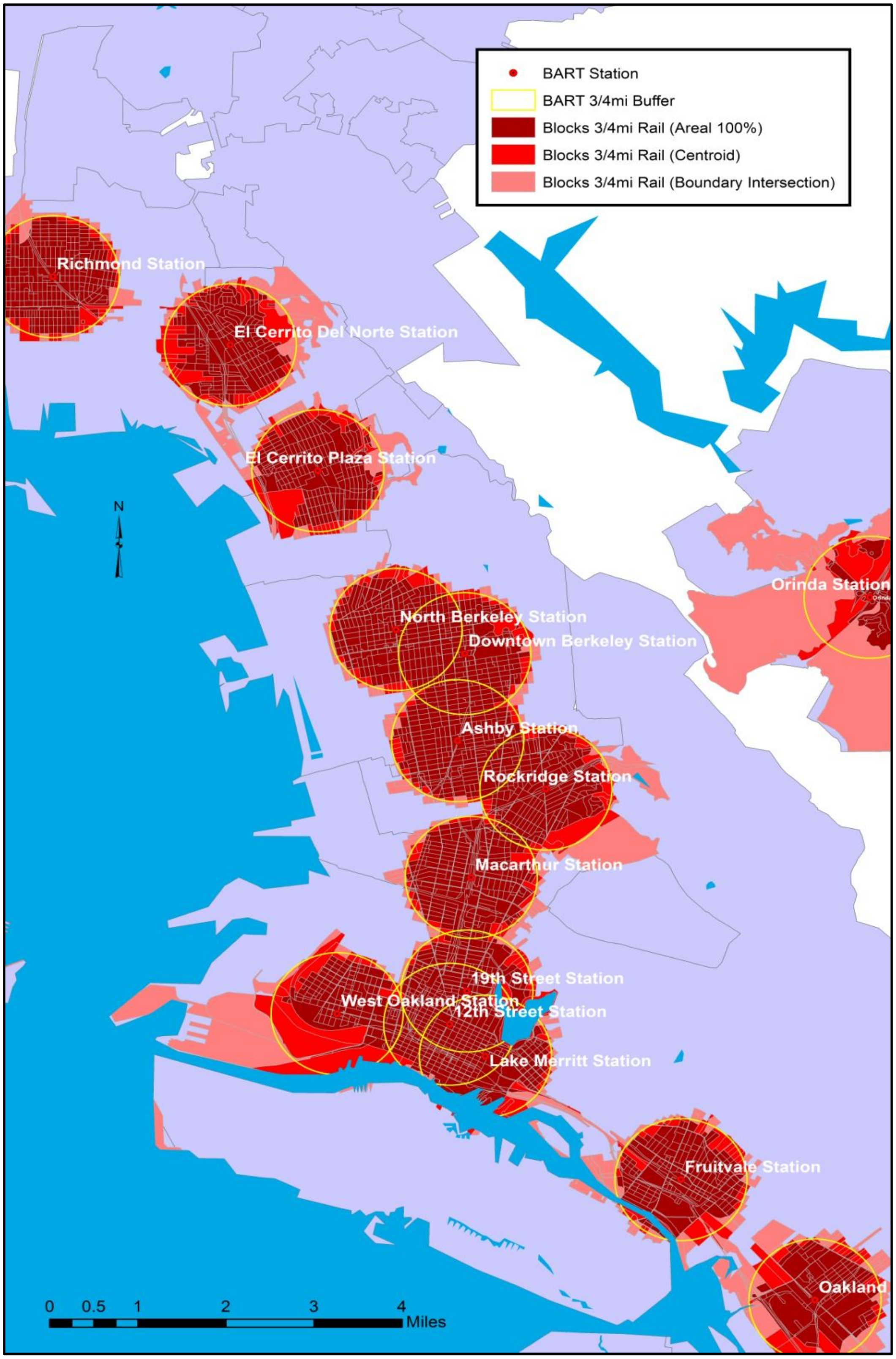

Figure 21. BART accessible blocks utilizing three-quarter-mile rail buffer.

In addition to these issues of buffer distance, the sensitivity of the selected blocks to the MAUP is another important consideration in order to understand potential variation in results due to geographic size and extent of census blocks. The following section examines this issue and discusses the significance of areal representation unit selection.

Areal Representation Unit Comparison

Figures 22 and 23 illustrate the impacts of areal representation selection under two diverse urban environments. In Figure 22, accessibility to BART stations in the downtown Berkeley area was analyzed by the three methods of boundary intersection, centroid containment, and complete areal containment. As can be seen on the map, the extent of the block areas is fairly uniform with the buffer itself, with only a few blocks reaching far beyond the buffer line (e.g. blocks on the eastern edge of the Downtown Berkeley station). This can be explained in large part by the higher block density and smaller size of census blocks in the area, due to the predominately urban nature of the environment, consisting of higher density, gridded street patterns, and traditional urban neighborhood design.

In stark comparison, the Orinda BART station (Figure 23) demonstrates highly differential impacts of areal representation selection. In this case, even the areal-containment method fails to capture all census blocks concentrated in close proximity to the station, while vast stretches of land far beyond the buffer are included under the centroid-containment and boundary-intersection methods. In this situation, the station area is surrounded by a lower concentration of much larger census blocks, dictated by the low-density planned-unit developments nearby in this predominately automobile-dependent neighborhood. Both of these examples highlight the high degree of variability to the MAUP

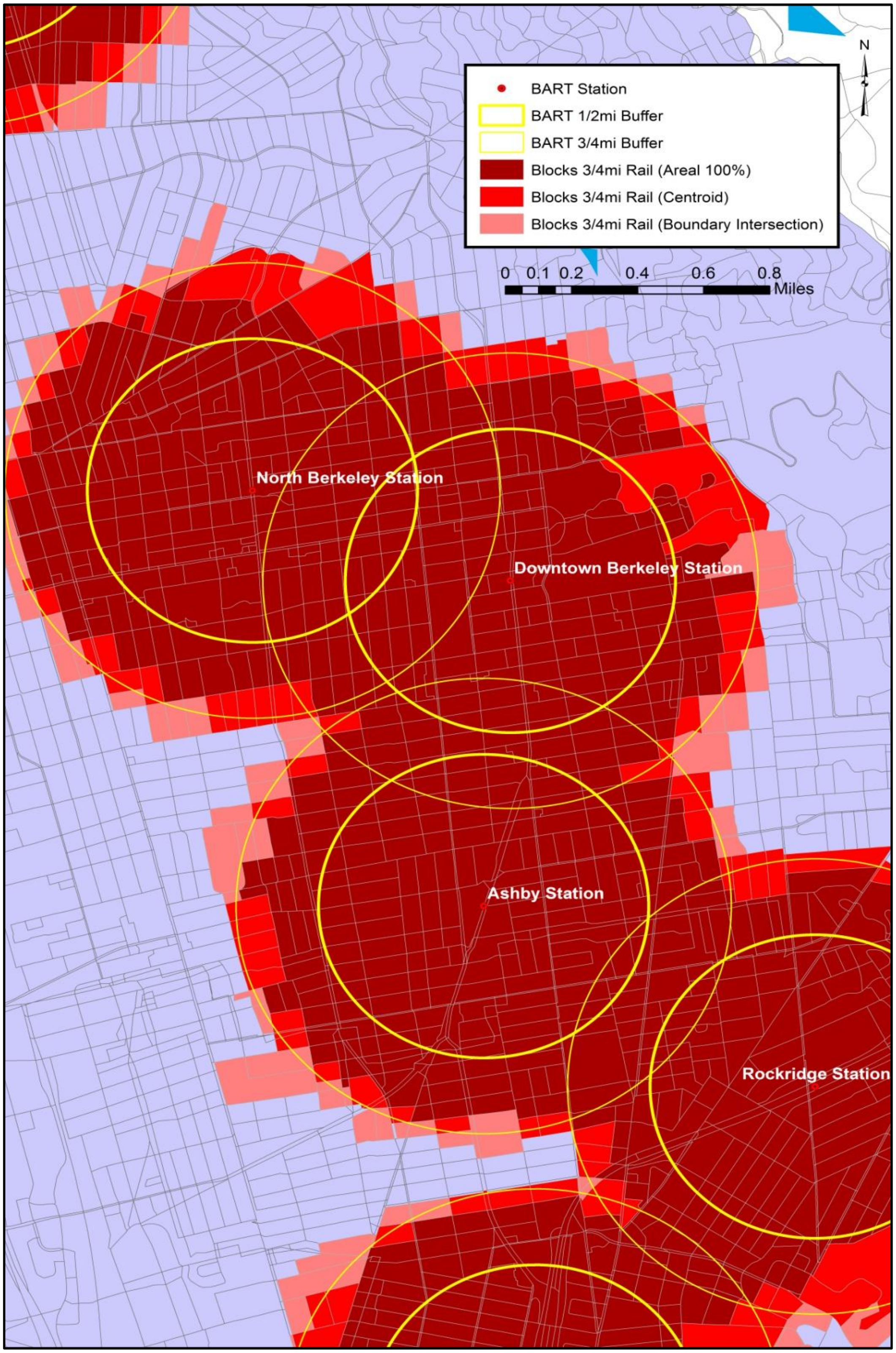

Figure 22. Berkeley BART stations accessible census blocks.

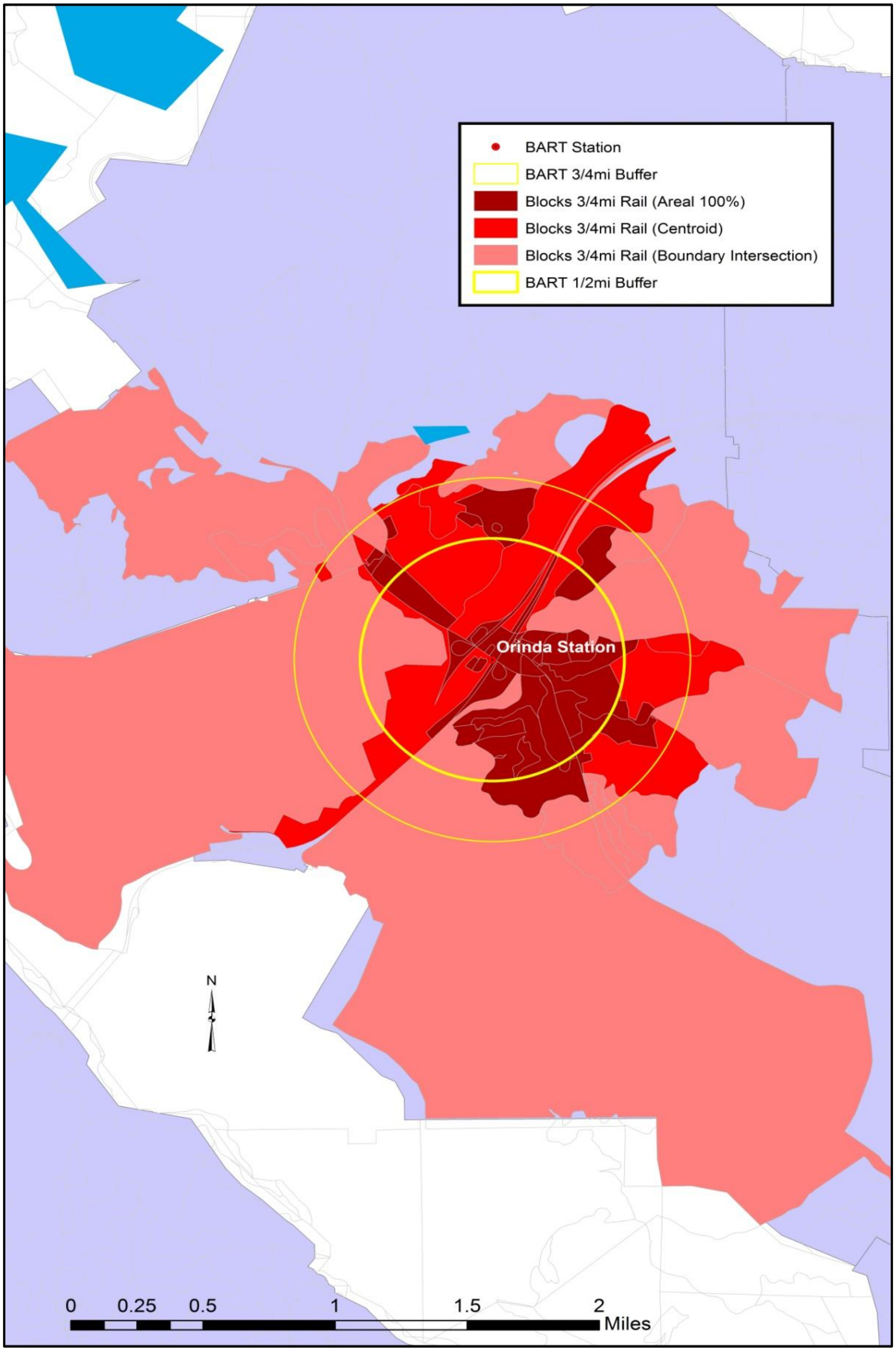

Figure 23. Orinda BART station accessible census blocks.

depending on the type of environment (e.g. urban core, suburban, rural), which in large part dictates the size and extent of census block coverage. Due to the combination of all environment types within the nine-county study area, these variances and their impact on overall results are important to consider and were therefore the focus of the next level of analysis.

San Francisco-Bound Commuters with Alternative Mode Access

By overlaying the location of low-income San Francisco-bound commuters on the census blocks designated as accessible (as illustrated in Figure 24) , the next step involved analyzing the impacts of MAUP when determining the number of such disadvantaged commuters. Figure 25 graphically highlights these differences that result from areal representation choice. Under the weakest approach (boundary intersection) utilizing an extended buffer, a total of 21,279 low-income commuters are considered accessible to direct rail service. This number falls to 19,264 under the centroid-containment method, and 17,154 with the areal-containment approach. The graph also illustrates the impacts of buffer selection. Under a conventional half-mile buffer in place of the extended method, the number of accessible low-income commuters would drop by 39 percent (boundary intersection), 44 percent (centroid-containment), and 49 percent (areal-containment) respectively.

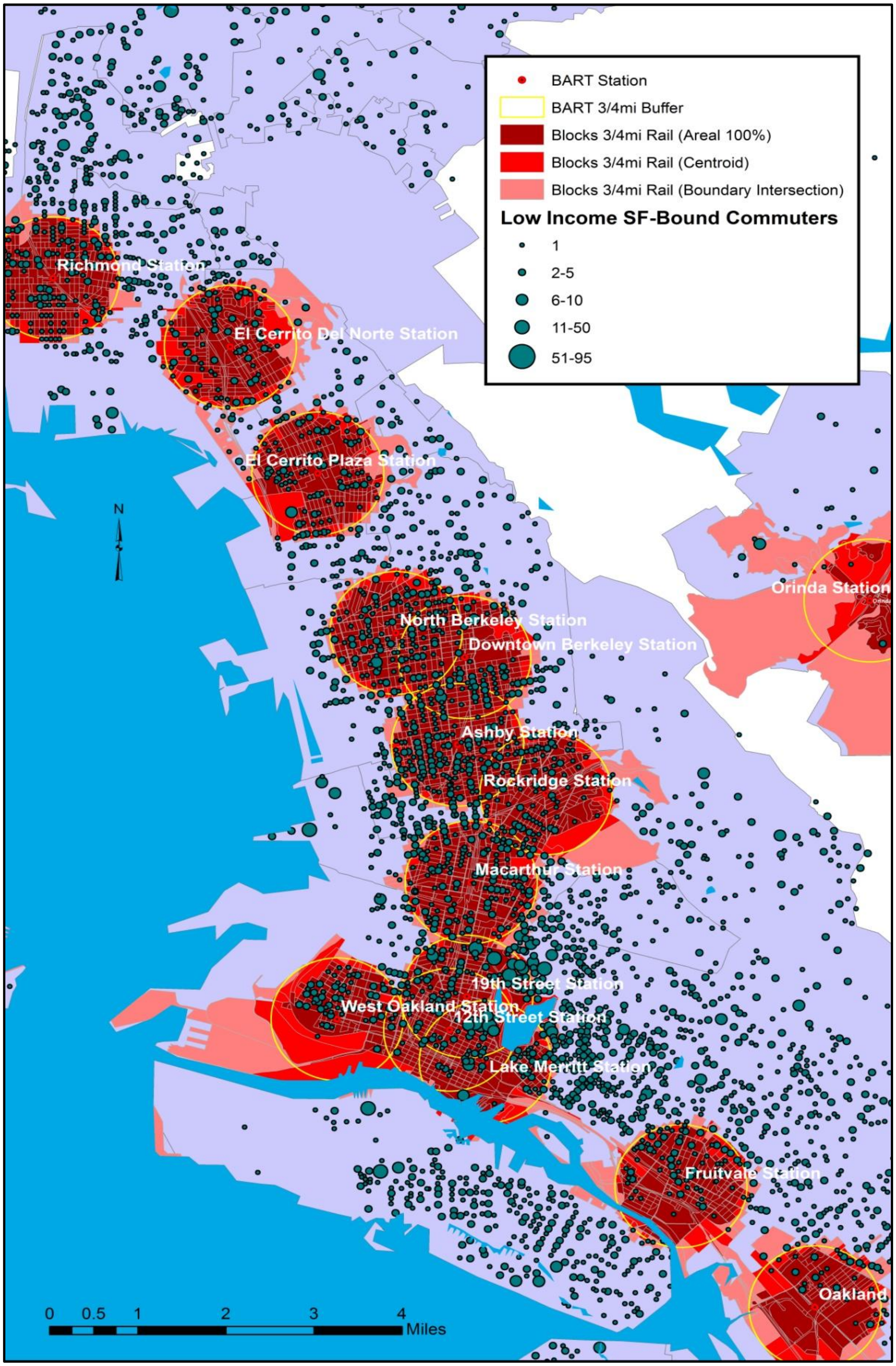

Figure 24. BART accessible blocks and SF-bound low-income commuters.

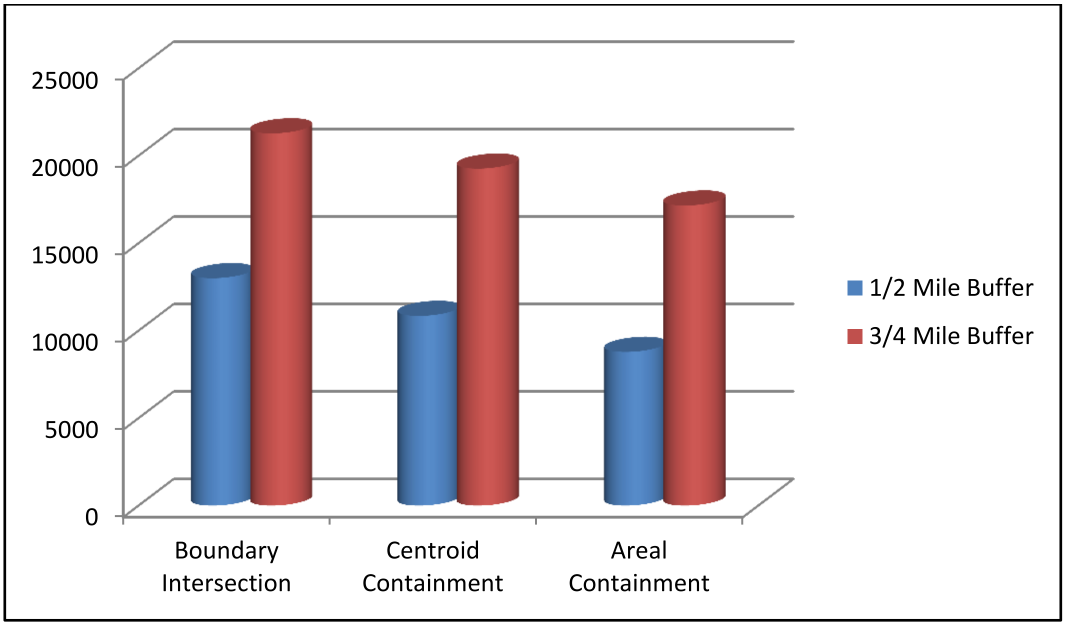

Figure 25. Direct rail-accessible low-income commuters by method and buffer.

When all direct and indirect access modes are considered, the total number of commuters lacking access to these options also exhibit significant differences based on selection of areal representation and buffer size. Figure 26 highlights the variance in number of commuters identified as living in inaccessible locations. As can be seen on the graph, those identified as lacking direct access range from a low of 11,620 (or 22 percent of all low-income commuters) under the more relaxed boundary intersection method with extended buffers, to a high of 19,714 (or 38 percent) under the restrictive areal-containment method with regular conventional buffering. If indirect access is also considered, the number of inaccessible commuters range from a low of 1,827 (3.5 percent of low-income commuters) to as many as 7,215 (13.9 percent).

In addition to differences in number of commuters selected under the three methods, the sensitivity of the spatial distribution of these commuters to areal representation choice was also examined. Figures 27-29 highlight the variation that can occur and the spatial

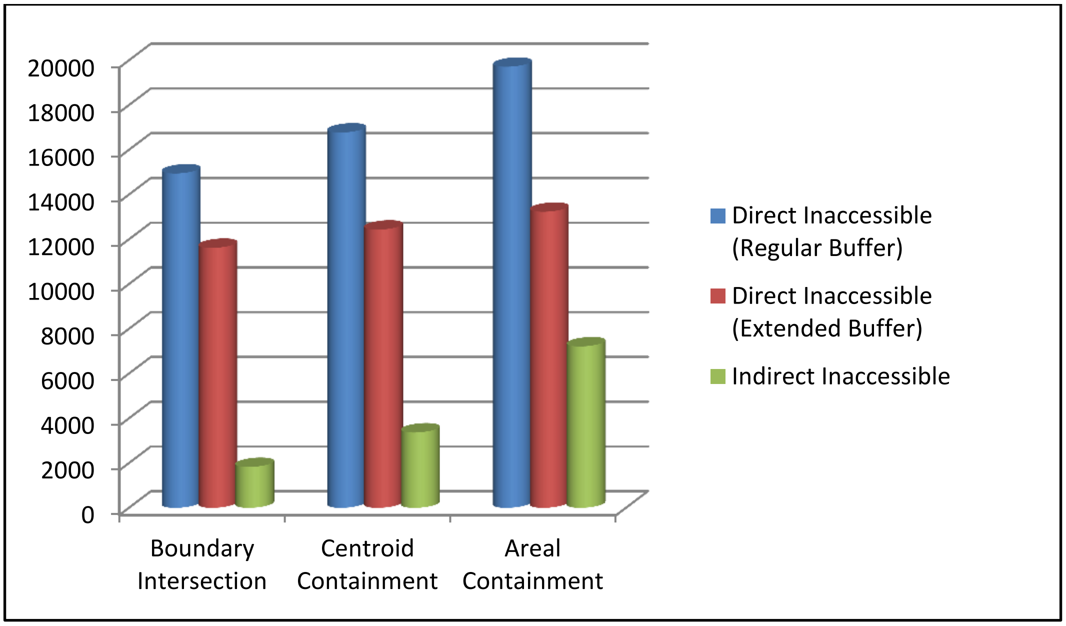

Figure 26. Direct and indirect inaccessible commuters by method and buffer.

concentration of these differences. In the North Bay (Figure 27), areas of Marin County (circled in red on the map) appear to have a clear divide between accessible and inaccessible blocks, regardless of method used. This part of the county contains pockets of highly inaccessible commuters, even under the boundary intersection method, while the majority of remaining residents are deemed accessible under all three approaches. Other areas of the bay, however, are much more sensitive to changes in method. In the East Bay (Figure 28) for example, the inland portion in the vicinity of Danville contains pockets of commuters (circled in red) who would be considered accessible under the boundary intersection approach, but change designation under the centroid and areal-containment methods. The South Bay (Figure 29) also contains areas with the same issue, including sections near Daly City and San Bruno (circled in red) which are invisible under the boundary intersection method, but become inaccessible under both other approaches. Failure to recognize these

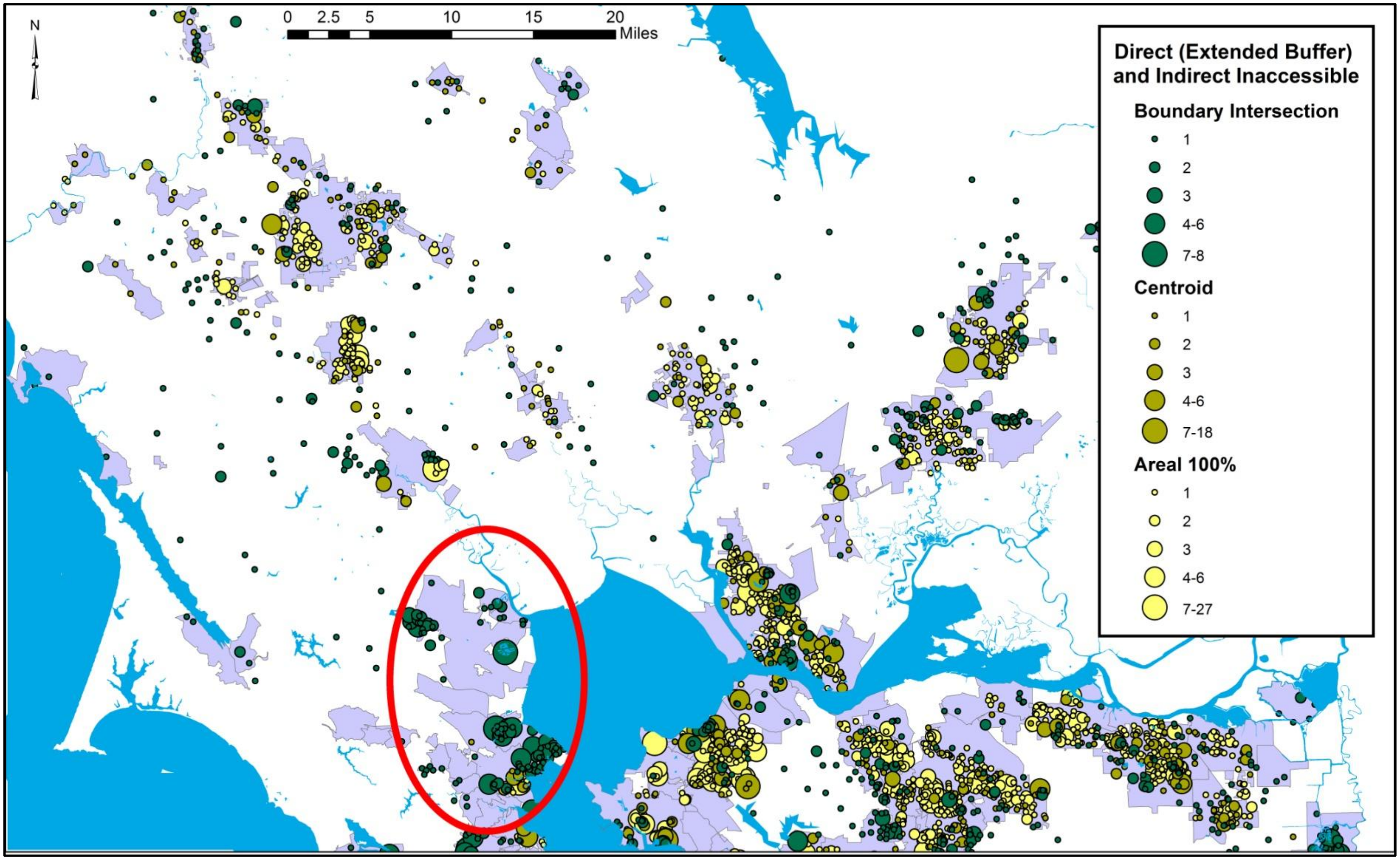

Figure 27. North Bay areal representation unit sensitivity of indirect accessibility.

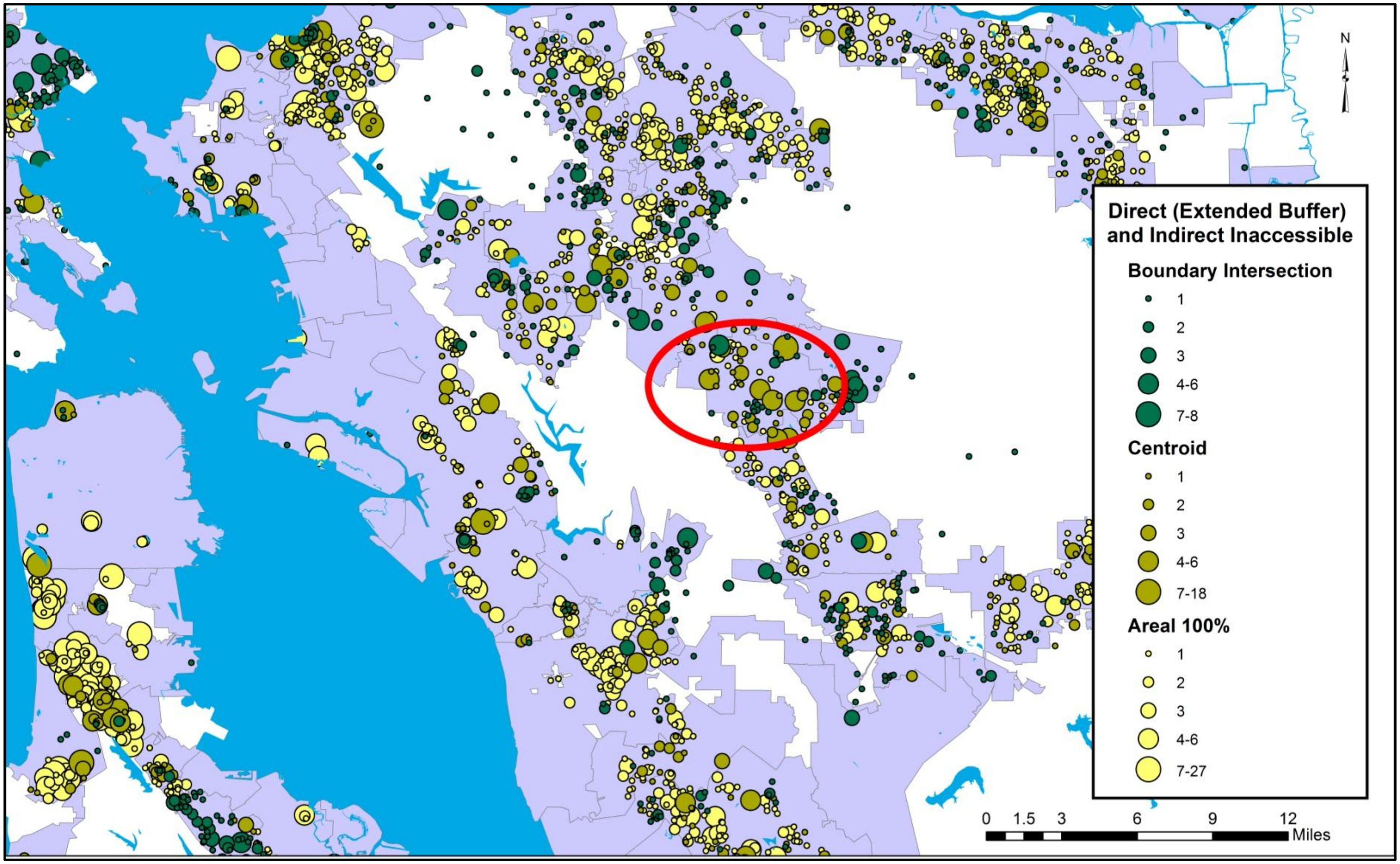

Figure 28. East Bay areal representation unit sensitivity of indirect accessibility.

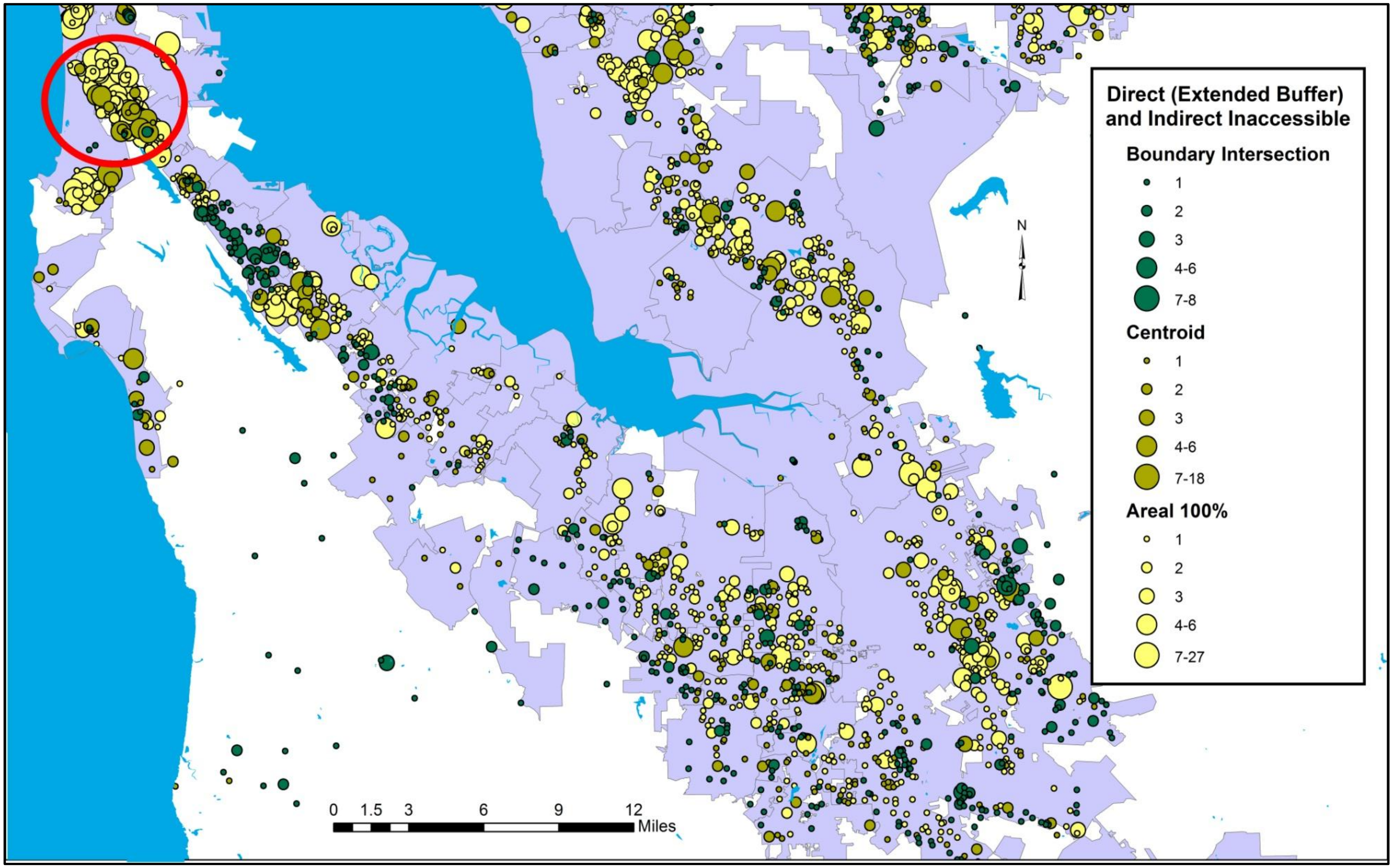

Figure 29. South Bay areal representation unit sensitivity of indirect accessibility.

differences by utilizing only one approach could hide the location of such disadvantaged commuters and reduce the ability to adequately mitigate disproportionate impacts.

Euclidean-Based vs. Network-Based Accessibility

The use of Euclidean distance-based buffers, as previously discussed, holds potential limitations for examining accessibility. One limitation, highlighted in Figure 30, is the inability to account for physical barriers that may limit accessibility, such as the case of the Fruitvale station. In this example, census blocks on Alameda Island appear as accessible under all three methods, yet are in fact limited by the barrier of a body of water.

An example of the potential variation of results by areal representation method and buffer size, in addition to issues of physical barriers under a Euclidean approach, is illustrated by the case of the downtown Oakland station areas (Figure 31). Blocks to the northeast of the 19th Street and Lake Merritt BART stations appear as accessible under different methods and buffers, yet the physical barrier of Lake Merritt may inhibit willingness to walk among these residents.

Although variations in results may exist between a Euclidean-based approach and a network-based approach, the confounding notion of precision versus accuracy illustrates how such concerns for pedestrian access are potentially insignificant. As noted by Boone et al. (2009), Guerra et al. (2011), and Weinstein Agrawal et al. (2008), network-based measures do not consider more direct-access pedestrian routes that do not follow street networks yet help pedestrians minimize walking distance. In addition, the uncertainty surrounding willingness-to-walk distances makes such “precise” methods for determining transit catchment areas seem unnecessary, particularly for the top-level analysis conducted in this research. Finally, arduous studies that attempt to precisely pinpoint the exact extent

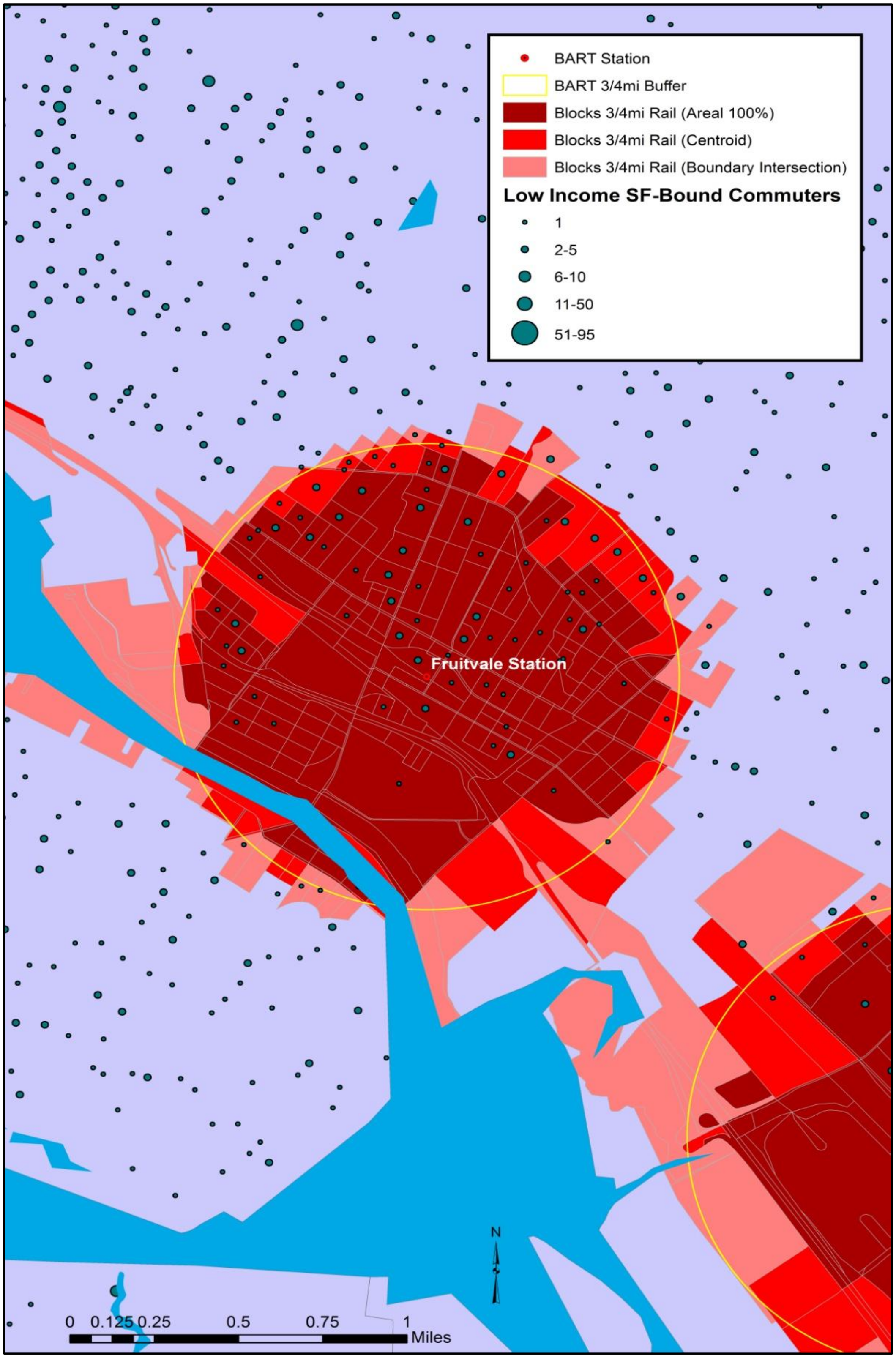

Figure 30. Fruitvale BART station accessible blocks using buffer analysis.

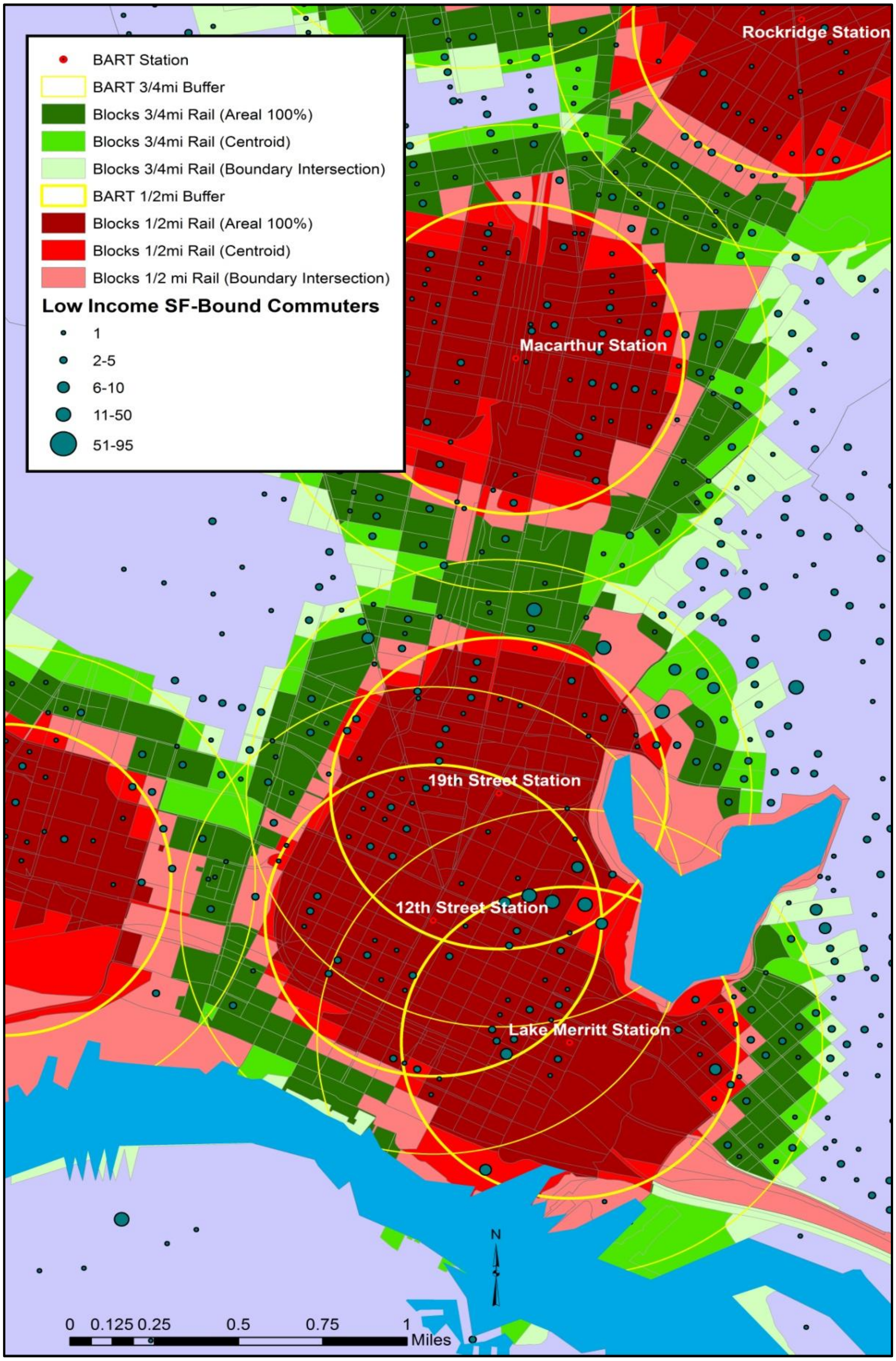

Figure 31. Oakland BART-accessible blocks and low-income commuters.

of pedestrian catchment areas fail to recognize the numerous other factors influencing a person's willing to walk that extend beyond mere distance of the trip. Although it is important to note any potential physical barriers that may confound results from a Euclidean-based approach, as illustrated in the Alameda and Lake Merritt examples, a network-based analysis does not necessarily guarantee improved accuracy of results, in spite of its enhanced precision.

Identification of Potential Communities of Concern

Based on the analysis conducted here, it is possible to identify potential communities of concern containing low-income commuters lacking adequate access to alternative transport options. Such communities can serve as candidates for a CIA, in which a more detailed analysis of potentially impacted low-income commuters would be conducted. This would include analyzing not only commuter location, but also commute time-of-day, the temporal component this is unavailable in LEHD data.

In Marin County (Figure 32), concentrations of inaccessible commuters can be identified in eastern San Rafael and in northern Santa Venetia. As these census blocks are inaccessible under all three methods, this suggests a complete lack of transit accessibility in the area. In Solano County (Figure 33), meanwhile, the cities of Vallejo and Benicia contain numerous commuters identified as inaccessible only under the centroid and areal-containment methods, warranting their inclusion in more detailed CIA analysis. The communities of Pinole and Hercules in northern Contra Costa County (Figure 34) exhibit the same phenomenon and also make good candidates for further mitigation analysis. In Southern Contra Costa County (Figure 35), the community of Danville contains concentrations of inaccessible commuters not accounted for under the boundary intersection method, while Blackhawk-Camino Tassajara has commuters lacking any form of transit access. In Alameda County (Figure 36), Fairview also contains commuters unreported by boundary intersection, while Castro Valley contains low-income residents in completely transit-inaccessible areas. Finally, in central San Mateo County (Figure 37), low-income commuters in Hillsborough lack transit access under all methods of analysis, while those inaccessible in Highlands-Baywood Park and the Daly City/San Bruno area (Figure 38) show up only under centroid and areal-containment methods. These examples are just a few of the communities of concern that can be identified by the analytical approach presented here and warrant further investigation to ensure disproportionate impacts are appropriately mitigated.

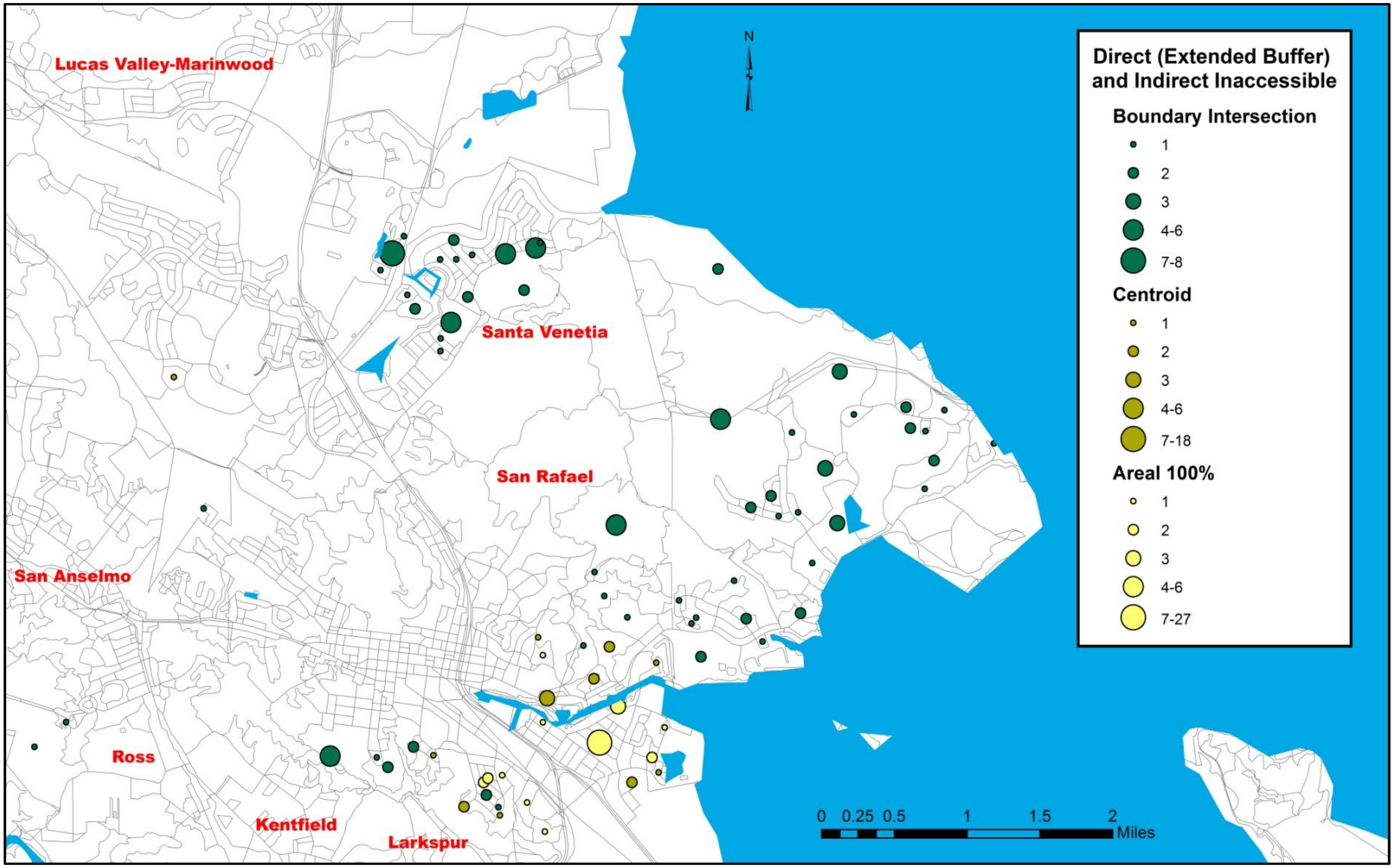

Figure 32. Marin County communities of concern.

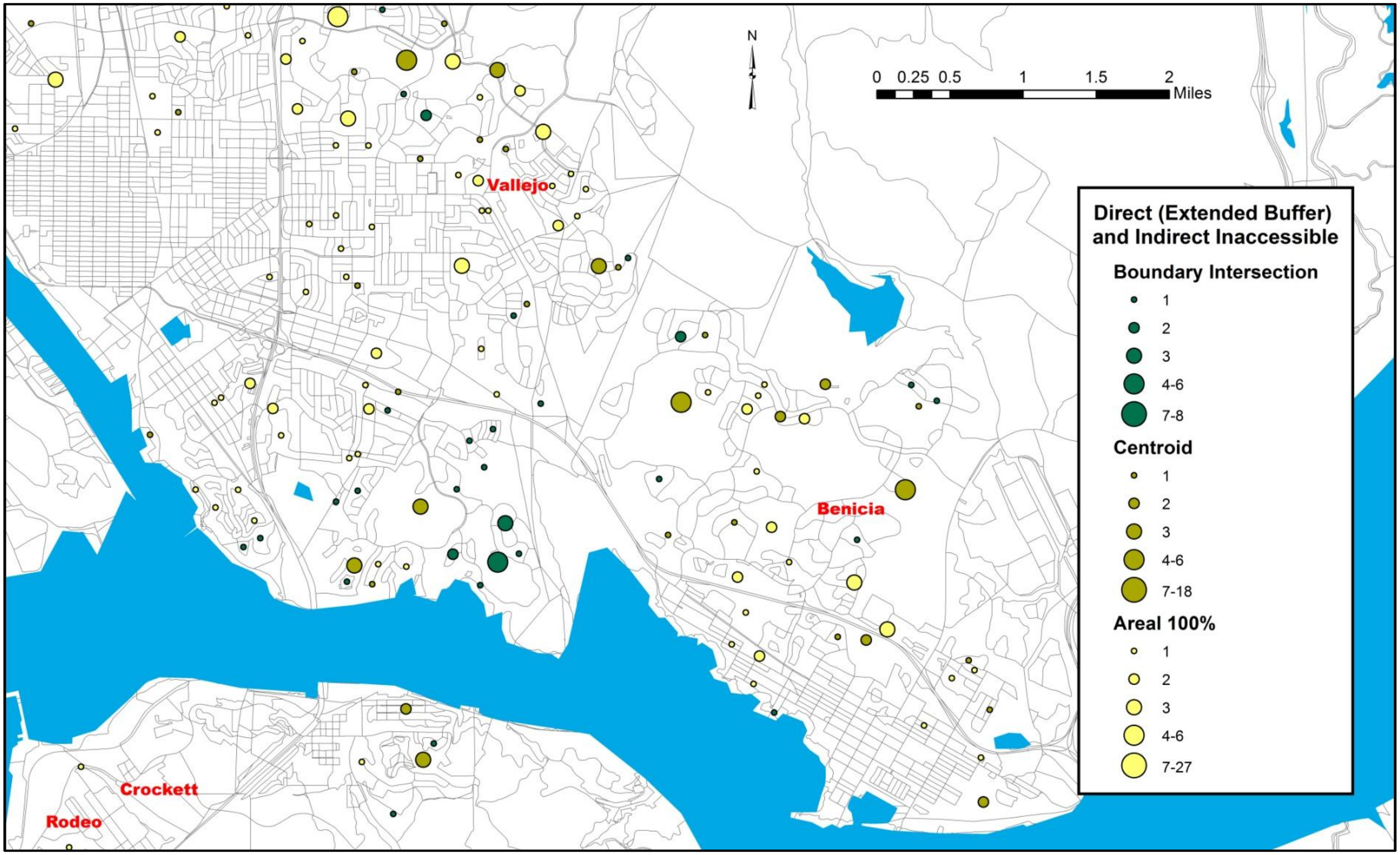

Figure 33. Solano County communities of concern.

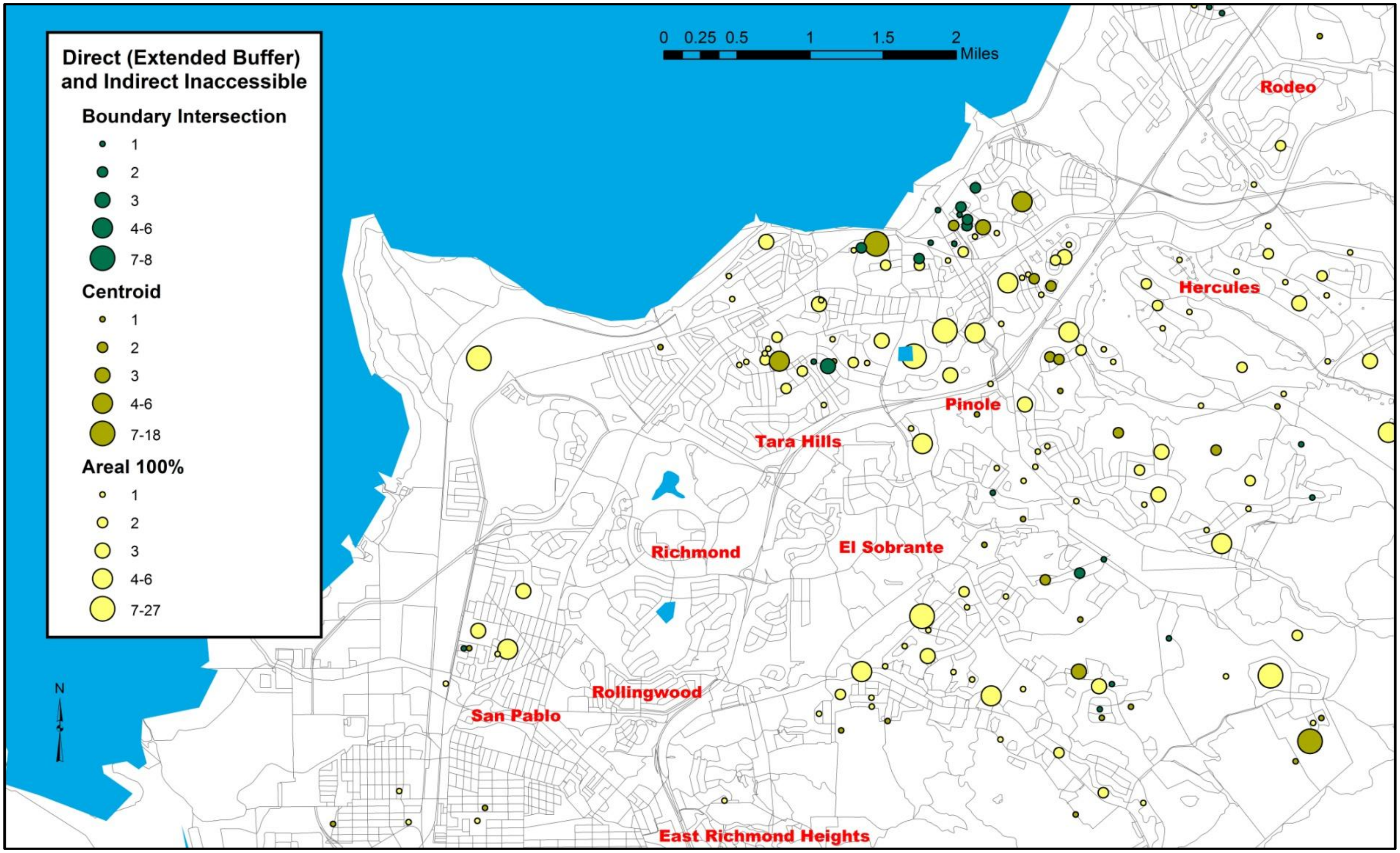

Figure 34. Northern Contra Costa County communities of concern.

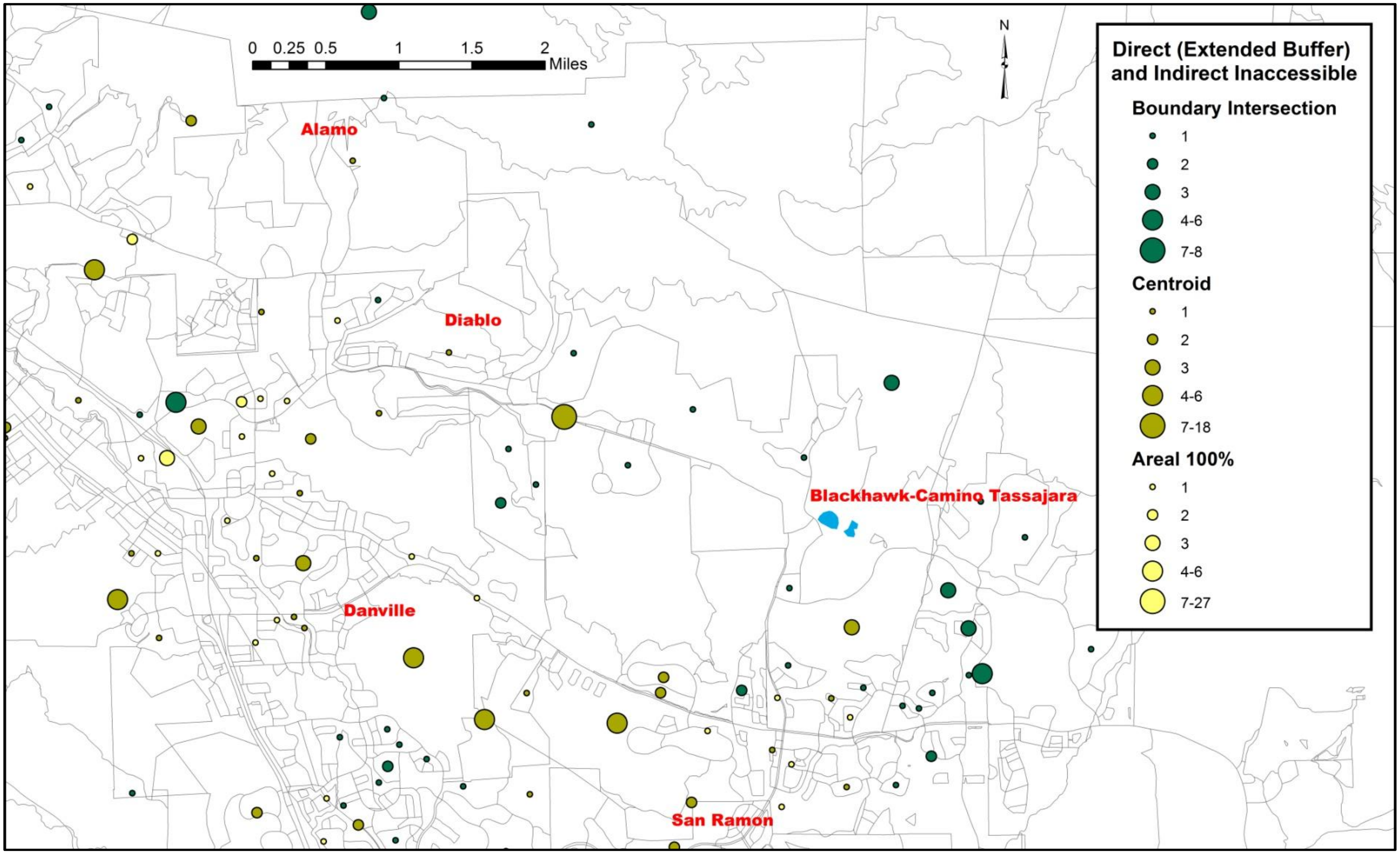

Figure 35. Southern Contra Costa County communities of concern.

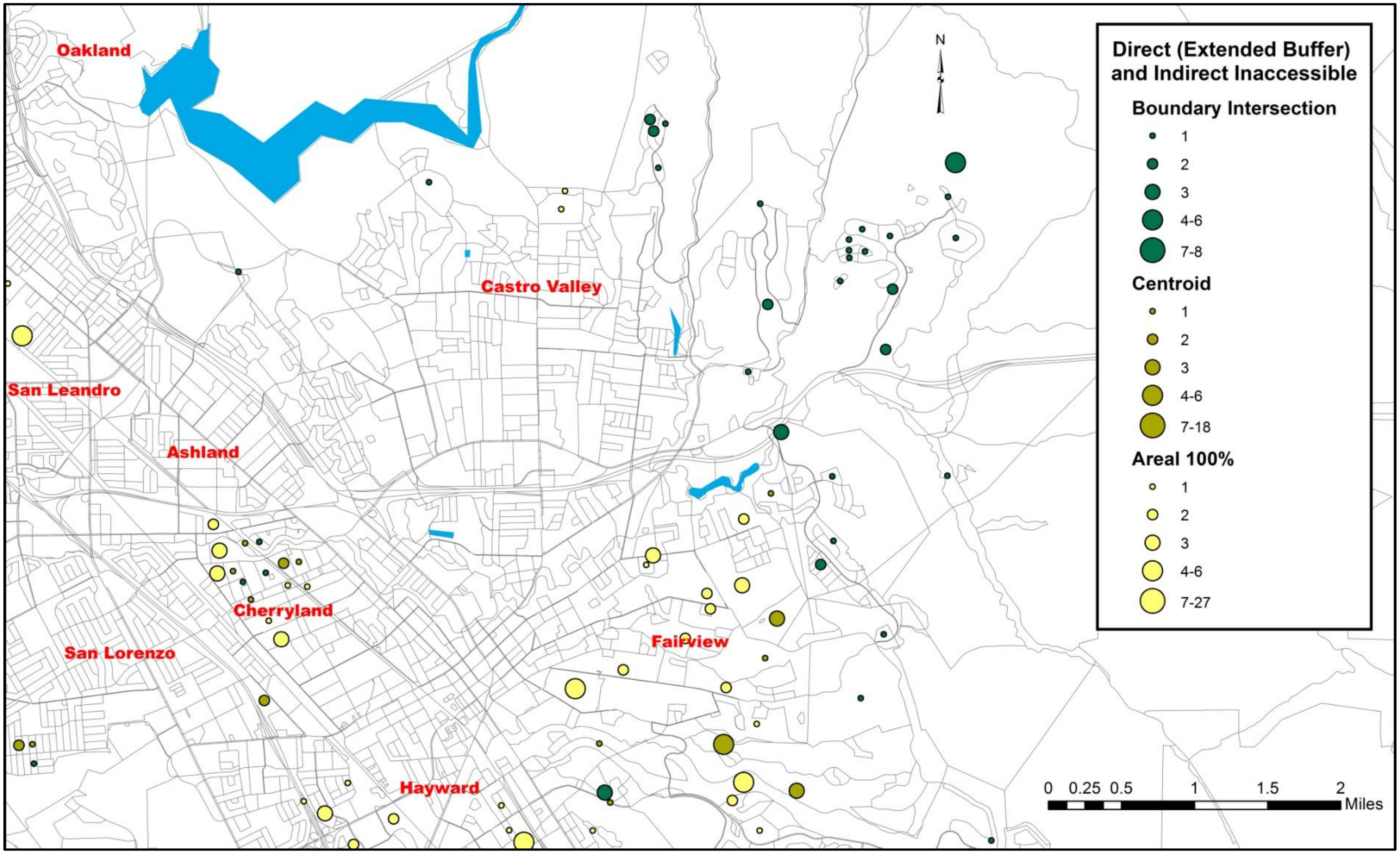

Figure 36. Alameda County communities of concern.

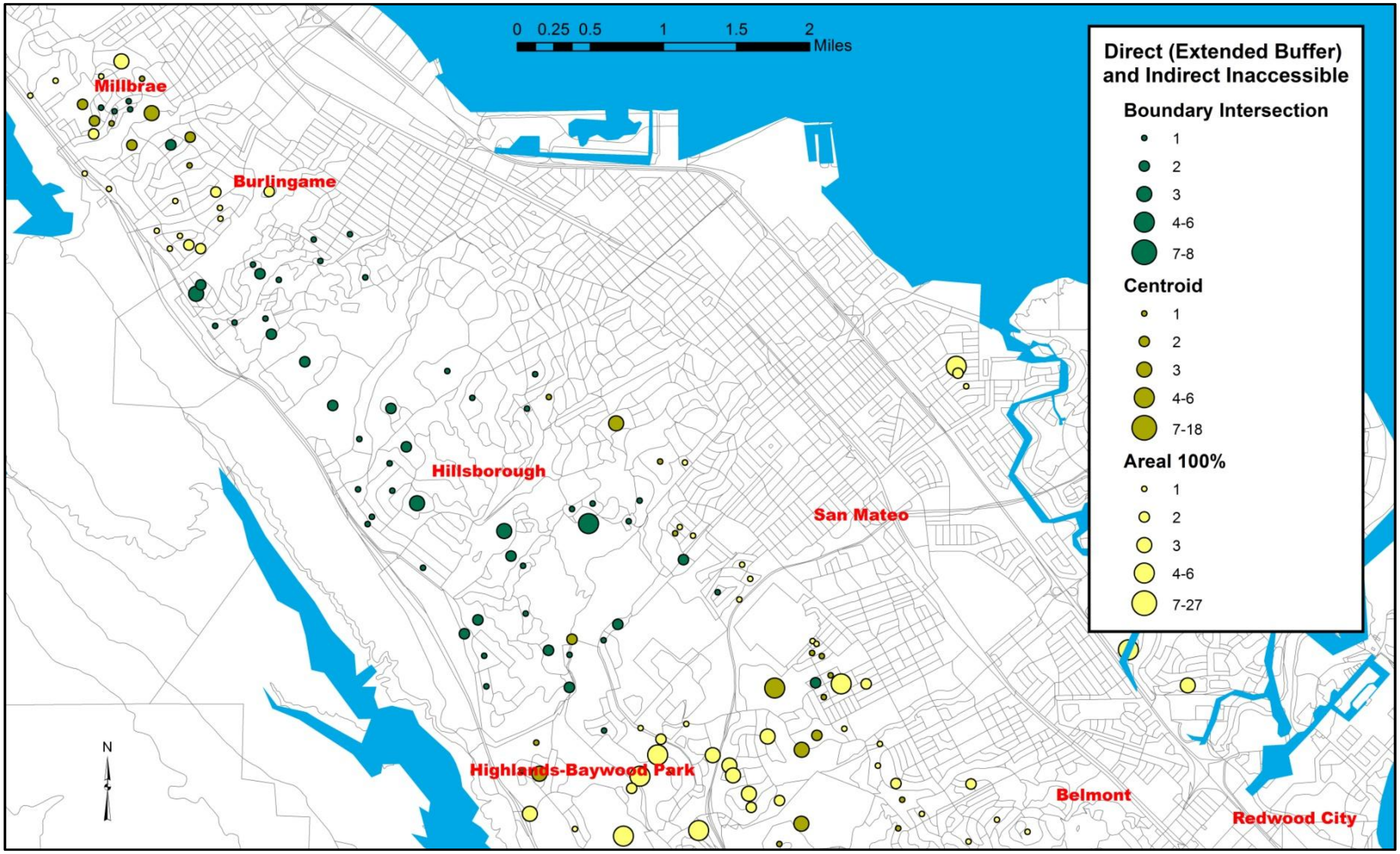

Figure 37. Central San Mateo County communities of concern.

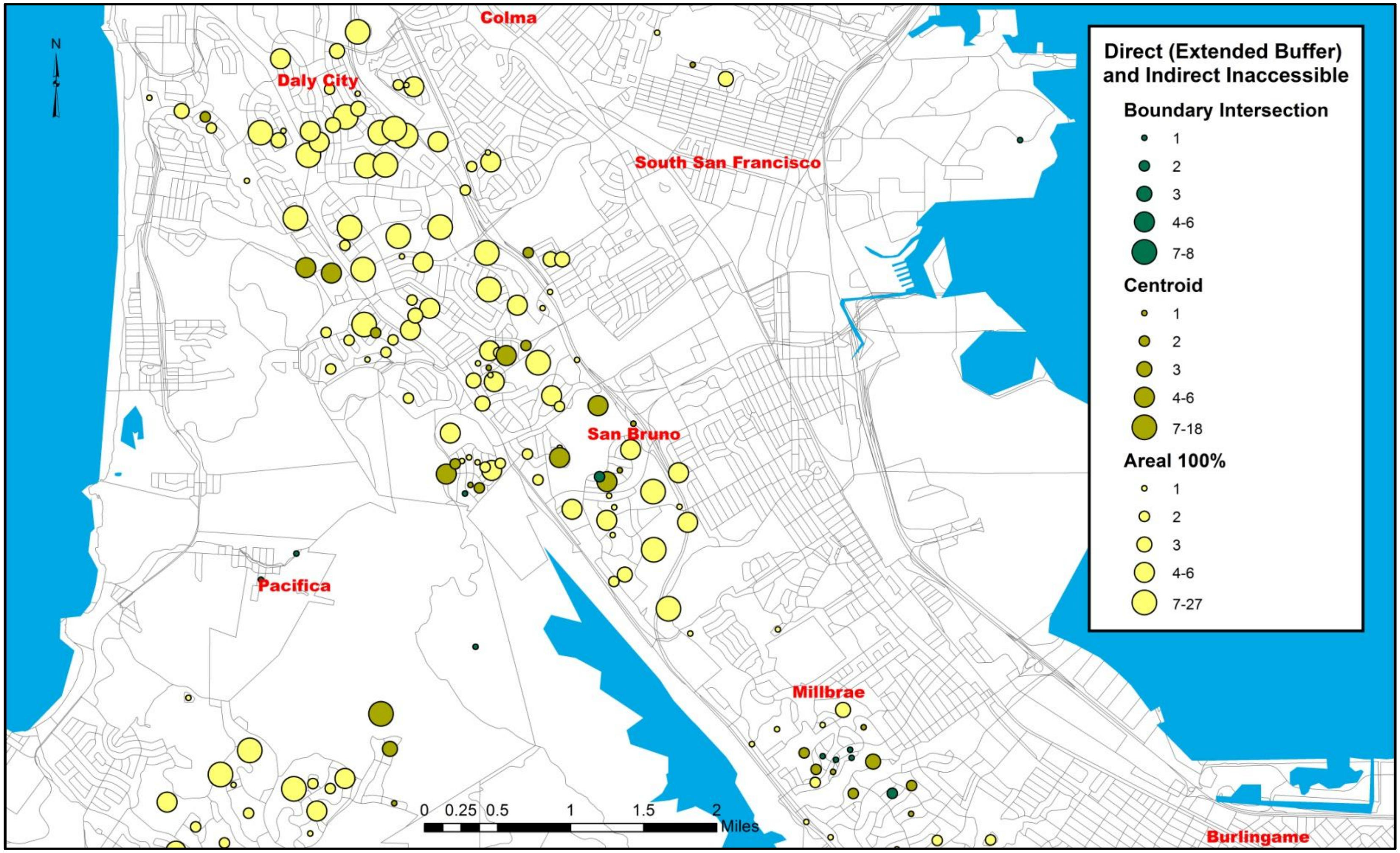

Figure 38. Northern San Mateo County communities of concern.

Chapter 7

RECOMMENDATIONS AND CONCLUSIONS

Future Research: Community Impact Assessments

The spatial analysis method presented here should be considered an initial step that better allows planners to target disadvantaged commuters. This top-level GIS analysis of potential communities of concern can next be utilized to conduct future in-depth CIAs to supplement and inform the underlying data and determine appropriate mitigation strategies in each particular context. By engaging local residents in problem solving and public participation in the form of a CIA, additional concerns and potential solutions may be identified, while disadvantaged populations can be given a voice in the planning process. As such, a CIA is an important step in any social equity analysis of cordon pricing.

Mitigating Income, Modal and Spatial Equity Issues of Cordon Pricing

The results of this study demonstrate how the spatial distribution of the toll-payment impacts of a proposed cordon pricing system in San Francisco may burden low-income residents in quite different ways, thereby warranting the inclusion of such analysis in transportation planning and practice. From a social-equity standpoint, it is necessary for planners to have an understanding of the income-based, modal-based, and equity-based issues associated with cordon pricing, and to recognize that low-income automobile-dependent peak-period commuters in areas with poor access to alternative modes are most vulnerable to differential impacts of such pricing systems. From a theoretical justice perspective, alternative mode-enhancing strategies appropriately targeted toward the least advantaged to mitigate such fee-payment impacts have the potential to produce a more "just" outcome than a blanket discount, when analyzed through a combined framework of egalitarian, utilitarian, and contractarian justice theories. The results of this research suggest that providing a blanket 50 percent discount to all low-income travelers as is currently recommended might unnecessarily hamper system efficiency by reducing overall cordon toll revenue generation, in addition to the system effectiveness by potentially encouraging rather than discouraging driving during peak hours, while failing to adequately address the social equity issues attached to this highly spatial and modal issue. Reinvestment of revenue in transportation-improvement projects targeted at the neighborhoods home to those most disproportionately impacted by tolling fees would not only help maintain the effectiveness and efficiency of the system, but would better address spatial-based horizontal equity issues, as well as income-based and modal-based vertical equity issues.

As noted in the FHWA (2010) report on congestion pricing environmental impact analysis, there is a particular need for the examination of issues related to geographic location and horizontal equity, including access to transit, access to private vehicles, and residential and work location, beyond a strictly vertical equity analysis examining differential impacts only income. Ecola and Light (2009) also conclude that the distribution of residents and job opportunities will have large equity impacts, while discounts and exemptions used to mitigate such impacts may hurt the effectiveness of congestion pricing by reducing the incentives that discourage driving. All of these findings point to the importance of analyzing spatial and modal considerations of equity in cordon pricing, in addition to income-related concerns, while developing mitigation strategies that maintain the efficiency and effectiveness of the pricing system.

Identifying the location of the effected population based on demographics, commute patterns, and alternative mode choice availability is essential in order to appropriately target such population with alternative mode-enhancing strategies. Inappropriately targeted transportation investments may not only provide minimal benefits for the least advantaged, but may also result in inefficiency, waste, and a loss in overall aggregate utility. These findings highlight how spatially-informed analysis is essential to such decision making.

This research demonstrates how transportation planners can address the income, modal and spatial equity issues associated with cordon pricing and mitigate disproportionate fee-payment impacts for disadvantaged commuters, while maintaining the overall efficiency and effectiveness of the cordon system. The method of analysis presented in this research utilizes common readily-available spatial and demographic analysis tools, yet it illustrates how only through a community-level contextual analysis can the distribution of those most disadvantaged be identified, allowing for spatially-informed reinvestment of revenue in access-enhancing projects in these areas. The findings of this research demonstrate the importance of including such community-level equity analysis in transportation planning practice. Though no specific policy recommendations can be concluded from this research, this dissertation provides a new conceptualization of equity issues in congestion pricing and mitigation strategies. As such, this research contributes to the scholarly body of knowledge on congestion pricing through both the theoretical justice framework presented and upon which it is based, in addition to the method of analysis proposed.

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