EQUITY CONSIDERATIONS FOR LONG-RANGE TRANSPORTATION PLANNING AND PROGRAM DEVELOPMENT

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EQUITY CONSIDERATIONS FOR LONG-RANGE TRANSPORTATION PLANNING AND PROGRAM DEVELOPMENT

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For my people.

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LIST OF SYMBOLS AND ABBREVIATIONS

ACI	Area Comparison Index
ACS	American Community Survey
AMI	Area Median Income
ARC	Atlanta Regional Commission
ASCE	American Society of Civil Engineers
BCI	Buffer Comparison Index
BRMPO	Boston Region Metropolitan Planning Organization
CAI	Community Attribute Index
CEQ	Council of Environmental Quality
CFR	Code of Federal Regulations
CLRP	Constrained Long-Range Transportation Plan
DOT	Department of Transportation
EPA	Environmental Protection Agency
ETA	Equitable Target Area
FEIS	Final Environmental Impact Study
FHWA	Federal Highway Administration

FTA	Federal Transit Administration
GAO	Governmental Accountability Office
GDOT	Georgia Department of Transportation
GPRA	Government Performance and Results Act
HUD	Department of Housing and Urban Development
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
LRTP	Long-Range Transportation Plan
LULU	Locally Unwanted Land Uses
MAP-21	Moving Ahead for Progress in the 21st Century
MAUP	Modifiable Areal Unit Problem
MPO	Metropolitan Planning Organizations
MTC	Metropolitan Transportation Commission
MWCOG	Metropolitan Washington Council of Governments
NEPA	National Environmental Policy Act
ODOT	Oregon Department of Transportation
PCI	Population Comparison Index
PSRC	Puget Sound Regional Council
RTP	Regional Transportation Plan

RTPP	Regional Transportation Priorities Plan
SAFETEA-LU	The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SSTP	State Strategic Transportation Plan
TAZ	Traffic Analysis Zone
TEA-21	Transportation Equity Act for the 21st Century
TIP	Transportation Improvement Program
TPB	National Capital Region Transportation Planning Board
UGA	Urban Growth Area
UGPM	Unified Growth Policy Map
USDOT	United States Department of Transportation
WIC	Women, Infants, and Children

SUMMARY

Transportation planning has become increasingly more performance-based over the past several decades. In part due the mandate from the 2012 Federal Surface Transportation Program authorization, Moving Ahead for Progress in the 21st Century (MAP-21), agencies are adopting performance-based policies and programmatic frameworks to integrate the attainment of national goals into the transportation planning and decision making process. As agencies implement performance-driven decision making as a means to achieve national goals, local goals will become subject to the same framework. Although equity is not a national goal, transportation agencies continue to recognize it within their vision and planning goals. However, it is difficult to determine what constitutes equity, and to quantify and measure it. To plan for equitable outcomes in transportation therefore, it is necessary to develop evaluation methods that support the integration of equity in the planning process. The overarching objective of this research is to develop recommendations for procedures to formally incorporate equity considerations in transportation planning and program evaluation. A companion objective is to propose methodological revisions to existing analytical processes to enable evaluation of cumulative accessibility outcomes. A literature review -- drawing from the theories of equity, Federal regulations for addressing equity in transportation, performance management, and transportation and sustainability -- and practitioner interviews were used to gather information on the common and effective practices for addressing equity in transportation planning at the regional level. This information was an input in the development of a quantitative research approach to explore methodological limitations and planning gaps related to transportation planning for

equitable outcomes. These results informed the development of a comprehensive approach to analyze and characterize cumulative impacts of the transportation system on accessibility and other measures of system effectiveness regionally. The approach was used to develop recommendations for regional transportation planning to influence equitable transportation outcomes for the full range of demographic groups over time. The research contributes to the knowledge base and professional practice of transportation planning by putting forward a construct for addressing equity in transportation planning and decision making based on equity theory, by developing analytical methods to evaluate transportation investments for equitable outcomes, and by offering a set of recommendations for moving transportation planning practices towards transportation planning for equitable outcomes.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Transportation planning has become increasingly more performance-based over the past several decades. Federal legislature has encouraged efforts to evaluate projects, programs and policies based on performance since as far back as the early 1990s (Amekudzi, Fischer, et al. 2012). In 2012, the Federal Surface Transportation Program authorization, Moving Ahead for Progress in the 21st Century (MAP-21), formalized a performance-based policy and programmatic framework for transportation investment. MAP-21 outlined seven national transportation goals and introduced performance management as the guiding principle for achieving these national strategic goals; it mandated the development of performance measures and the integration of these measures into the decision-making process through long-range planning.

As transportation agencies implement performance management principles in their planning procedures, they will measure progress towards not only national goals, but also the goals identified through their respective visions. While the national goals include environmental sustainability, several states have also identified sustainability accounting for environmental, economic and societal concerns, as part of their goals. For example, the Washington Department of Transportation (DOT), Oregon DOT and California DOT all include sustainability as part of their missions (Zhou 2012, WSDOT n.d., ODOT n.d, Caltrans 2015). In fact, in 2010, 40 percent of state departments of transportation included sustainability either explicitly or implicitly in their mission statements (Jeon et al. 2010). Sustainability has been defined in many ways in the literature. The Brundtland definition is perhaps the most commonly cited definition in the literature and defines sustainable development as "development that meets the needs

of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). The American Society of Civil Engineers (ASCE) provides one of the more comprehensive definitions of sustainability: "a set of environmental, economic and social conditions in which all of society has the capacity and opportunity to maintain and improve its quality of life indefinitely without degrading the quantity, quality or availability of natural, economic, and social resources (ASCE 2009)." Conceptually, developing sustainably involves enhancing societal and economic capital while preserving environmental capital.

Of the three types of capital that are typically called out in definitions of sustainability, social sustainability concerns, i.e. preserving and enhancing the well-being of communities over generations, have received less attention than the other two types of capital. Past studies of transportation agencies show the absence of societal values evident in the limited inclusion of equity in sustainability practices (Agyeman & Evans 2003); however, there is increasing awareness of the need to incorporate social factors, especially equity, into sustainability considerations in transportation planning (Pearsall & Pierce 2010). Including these factors is especially important because when social sustainability concerns are not considered along with other transportation concerns, they are not included in decision making for funding allocations (Johnson & White 2010). As transportation agencies continue to identify sustainability as a goal, social sustainability concerns must be formally included in the transportation planning process for a comprehensive approach to decision making for sustainable outcomes.

Although social sustainability encompasses several related concepts – social inclusion, participatory democracy, and social capital and cohesion – equity has grounding in federal requirements. Equity in transportation is most commonly seen through the lens of federal requirements for environmental justice and although this mandates incorporation of equity into federally-funded transportation practices, the level to which equity is included varies by agency (Amekudzi, Smith, et al. 2012). Agencies

are stipulated to engage in participatory planning and account for disproportionate burdens and equitable receipt of benefits. Still, procedures in several agencies do not reflect incorporation of environmental justice analysis results and feedback into the decision-making process (Amekudzi, Smith, et al. 2012). As mentioned, neglecting to incorporate equity into the decision-making process excludes it as a factor in the planning process. This research explores how equity can be formally considered within a performance-based planning framework to attain regional sustainability goals and equitable outcomes for the transportation system.

More specifically, the purpose of this research is to identify avenues to formally incorporate equity considerations within a performance-based planning framework and provide guidance to support addressing equity in long-range transportation planning. The research identifies gaps in equity evaluation methods currently used by transportation agencies and their limitations in planning for equitable outcomes. A literature review and review of case studies were conducted to characterize the state of equity considerations and gaps in long-range transportation planning. Methods were proposed to address existing gaps. Subsequently, existing equity evaluation methods and proposed methods to address the gaps were applied to a primary case study to demonstrate how the proposed procedures address existing gaps and showcase a practical example. Based on the results and guided by the literature and case studies, a set of recommendations for equity considerations in long-range planning was developed. The recommendations outline how equity can be formally considered in long-range regional transportation planning to influence outcomes.

1.2 Problem Statement

The transportation system is a necessity for a functioning society and is built and supported by public funding at the local and federal levels. As with such public goods, fair distribution is relevant. The pluralistic concept of equity is based on fair treatment

and can be used to construct the idea of fairness. Equity can be explained in the balance of the three criteria of social justice: equality, needs and deserts (or rewards) (Young 1994, Khisty 1996). Achieving equity of transportation outcomes across populations and/or geographic areas involves integrating these three criteria while accounting for the needs and inputs of all system users and non-users impacted by the system. Still, what constitutes an appropriate balance between these three criteria is relative and the various conceptualizations of equitable distributions make it is nearly impossible to definitively say if an outcome is or is not equitable.

The equity evaluation processes most commonly used in transportation are variations based on the quantitative analysis for environmental justice outcomes. The goal of such evaluations is to determine if there are disproportionate impacts on a particular population (Forkenbrock 2004); in essence, to determine if there is or is not equity. The research in this dissertation applies several methods for evaluating equity on a primary case study, not in an attempt to determine whether or not there is equity, but in order to test how methods assess equity of access. The study uses this application to identify limitations in the processes that are currently used in transportation practice to address equity and proposes and tests improvements to address these limitations. The method that is proposed in this research is not a wholly new method; rather it is a novel framing of the environmental justice analysis process. This research approaches the quantitative analysis differently, allowing for more precision in the analysis and providing more information for decision making to achieve equitable transportation access. It does not develop new tools, but evaluates existing tools, presents process improvements and modifies the analysis to offer a new way to evaluate the results that is more aligned with equity theory and balancing the three criteria.

The quantitative analysis for environmental justice outcomes focuses on impacts for target areas. A major difference for the proposed method is that it does not focus on a particular population but focuses on an impact, or the effects of transportation

improvements for all populations. The impact evaluated in this research is accessibility, or the ease of reaching destinations. Accessibility is the primary reason for travel and increasing the ease of reaching destinations is a principal reason to improve transportation infrastructure. Without the ability to reach destinations such as jobs, schools, health care facilities, grocery stores and other basic needs, citizens are not served by their transportation system and having the opportunity to reach destinations such as parks, museums, and other discretionary destinations improves quality of life. Gaps between the levels of accessibility across the population can be identified by an evaluation process that looks at cumulative and comprehensive impacts of the transportation system over time, who they are affecting and how those people are being affected – and they can be addressed by feeding this information formally into the transportation decision-making process to influence resource allocation for more equitable outcomes.

The proposed approach shows gaps in performance for regional accessibility, not just disproportion among populations. The areas that are under-served are identified and the residential patterns in these areas can be analyzed to provide useful information for equity considerations across populations. The demographic profile of under-served areas can also be compared to areas that are well-served for a more comprehensive analysis of equity. Expanding the analysis past target areas also allows impacts on additional demographic groups to be evaluated within the same analysis without many additional resources.

Framing the analysis around impacts and not populations provides more precision in determining what populations are affected and how. Populations that are disadvantaged by the improvements can be evaluated in more detail determining how they are disadvantaged and what improvements are needed. Additionally, to enhance the identification of necessary improvements, public outreach efforts can be targeted to areas that are disadvantaged. This framing helps explore the gap between the disadvantaged

and the advantaged linking equity evaluations more closely to equity theory. This process expands equity beyond recompense for historic disadvantage, which motived the environmental justice movement, and focuses on current impacts of the transportation system in addition to addressing historical disadvantage's lingering effects.

In the current state of practice, equity often lacks influence on decision making (Agyeman 2003, Pearsall 2010). The findings from the analytical comparison of methods are placed within the performance management framework to position outputs for consideration in future planning to approach equity goals over time. Performance management is an ongoing, systematic approach to improving outcomes with the use of evidence-based decision making, continuous organizational learning, and an emphasis on accountability for performance (Kane 2010). It follows that setting equity goals and taking equity considerations into account throughout the planning process will support equitable outcomes. In this way, the dissertation approaches the disconnection between procedural and outcome equity by positioning the work within the planning procedures, to make the connection between planning for equity outcomes and returning equity outcomes. Additionally, the iterative nature of performance management tracks performance towards equitable outcomes over time. This is an improvement over the standard practice and changes the evaluation outputs from being a final check to being incorporated into the planning process.

The dissertation outlines both methodological and planning limitations. The research audits methods from practice and literature that are used to evaluate the demographics of a region, the impacts of the regional transportation improvements and the distribution of the impacts with respect to the regional demographics. It highlights the current inability to evaluate the equity of regional outcomes that result from improvements over time, or cumulative impacts, and adds robustness to the environmental justice process that is often used for equity evaluations by building in theory-based equity considerations. It also positions the process within long-range

planning to advance Equitable Transportation Planning as a component of performance-based planning. This research does not create an implementation plan but identifies ways to operationalize the approach by placing it in the performance management framework for incorporation into decision making. In doing so, it helps to place equity in a position to be considered in conjunction with other performance goals for a transportation system.

1.3 Objectives

The overarching objective of this research is to develop recommendations for formal procedures to incorporate equity considerations in transportation planning and program evaluation at the regional level. It develops an approach for a proactive, demographically-nuanced analysis at the regional level to characterize accessibility to regional opportunities and applies this framework to demonstrate recommendations for regional transportation planning that will contribute to equitable transportation options for the full range of demographic groups within a region. To meet these objectives, a set of research questions were used to guide the research.

- How does one develop a demographic profile within a practical spatial unit of analysis to inform transportation program development?
- How can one identify the level of equity of an impact across a region?
- How can evaluation methods inform the long-range planning process to influence equitable outcomes?

How does one develop a demographic profile within a practical spatial unit of analysis to inform program development?

This question addresses the gap between current equity evaluations and equity theory and reflects the need to create a demographically-nuanced analysis that provides a more precise understanding of what demographic segments are impacted by transportation improvements and how they may be impacted. The question also takes

into account the need to balance methodological sophistication with adaptability for practical application.

How can one identify the level of equity of an impact across a region?

This question focuses on the equity evaluation and essentially asks how can equity be "measured" and what makes a distribution equitable. The answer directs how equity is positioned within the planning process. The answer is meaningful in order to understand not only how performance towards equitable transportation outcomes should be measured, but also how goals for such outcomes should be set.

How can evaluation methods inform the long-range planning process to influence equitable outcomes?

The final question addresses the formal incorporation of equity considerations into the planning process. It answers how the considerations can be applied to the process and how that relates to desirable outcomes.

1.4 Overview of Methodology and Contributions

This dissertation used a mixed-methods approach to research. Qualitative data was collected via literature, reports, planning documents, and first person interviews were conducted with practitioners to substantiate the findings. The information collected helped to develop the quantitative research methodology. The research followed the framework shown in Figure 1. Four areas of literature – equity theory, environmental justice, sustainability, and performance management – were reviewed to provide the foundational knowledge base for this research. Equity theory was explored to understand how equity has been defined and how it has been operationalized, especially in the context of transportation. Transportation equity is often held within environmental justice and a literature review of environmental justice in transportation was conducted to identify evaluation practices that are currently used. Transportation equity can also be

seen in discussions on sustainability; therefore, sustainability in transportation, especially with respect to social sustainability was studied. Finally, research on performance management and regional transportation planning described practices used in developing long-range plans and transportation improvement programs. The literature review was used to establish the concept of Equitable Transportation Planning, which identified gaps in practice and guided the remainder of the research.

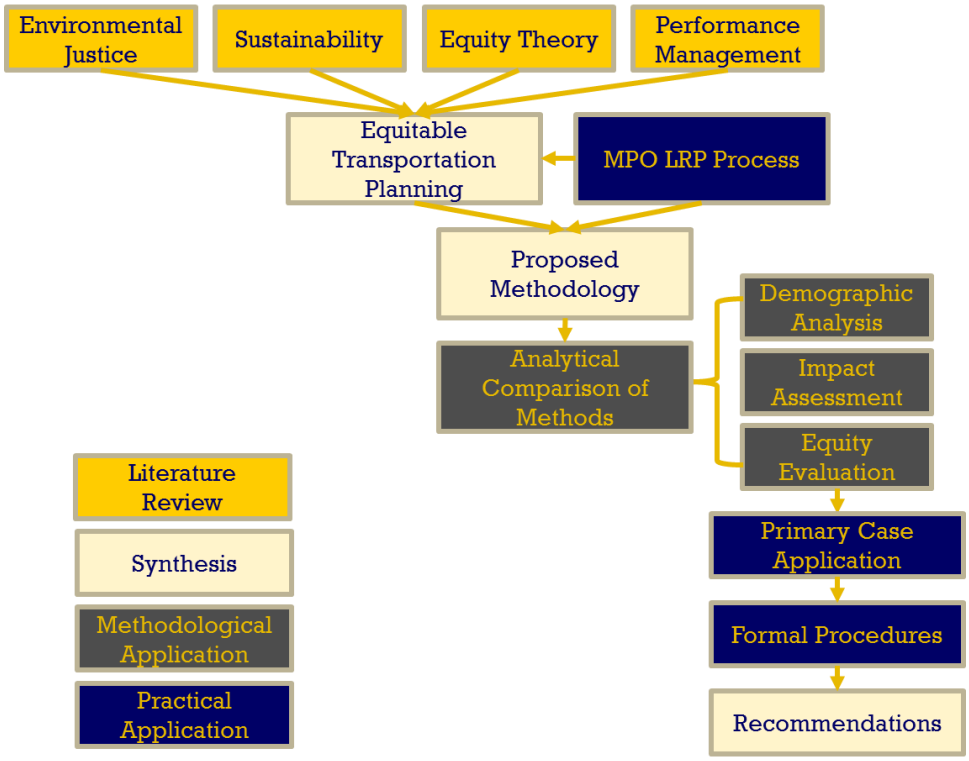


Figure 1 Research Framework

The literature review is supported through a review of the long-range planning process for four metropolitan planning organizations. The case study review of these MPOs reflected the state of practice and evaluated how the MPOs applied the values of Equitable Transportation Planning. The case studies reviewed long-range transportation plans and additional planning documents to identify which analysis methods from the literature were being applied in equity evaluations for long-range planning processes and how the results were being used. The case studies focused on the incorporation of equity

into the vision and regional goals of an MPO, the process used for developing the transportation improvement program (TIP), and the method for evaluating equity especially as it relates to accessibility. The results of the case studies were validated through interviews and reviews by key staff at the respective MPOs.

Equity evaluation methods used in practice were tested and a proposed method was developed based on the results of the qualitative research, specifically the gaps identified, and the concept of Equitable Transportation Planning. The quantitative analytical comparison of methods explored various methods to approach three analyses: demographic analyses, impact assessments and equity evaluations. Using the Atlanta Regional Commission (ARC) as the primary case study, demographic analysis methods from the literature and from practice were used to create demographic profiles based on US Census and American Community Survey data and the results were compared for sensitivities. The results were also compared to a method of studying the distributions of populations proposed by this work. An impact assessment for accessibility was conducted using transit travel times from OpenTripPlanner and automobile travel times from the travel demand model provided by the Atlanta Regional Commission transportation department. Spatial analyses were completed using GIS shapefiles of census tracts, traffic analysis zones, regional centers, transportation infrastructure and other regional significant geographies from the MPO's database. The results of the impact assessment were used in concert with the demographic analysis to test equity evaluation methods, identifying limitations of commonly used practices and applying various methods to address these gaps.

The results led to a set of recommendations for equity evaluation and long-range planning to support Equitable Transportation Planning. Using the performance management planning framework, formal procedures were developed to incorporate the results of the analysis into long-range planning to influence equitable outcomes.

This research contributes to professional knowledge and practice, and bridges professional practice with the theories of equity. The research develops the concept of Equitable Transportation Planning; it defines critical components of the concept and shows its validity for practice. By conducting sensitivity analyses of current environmental justice practices, this research empirically shows the limitations of the quantitative method most frequently used to assess equity in transportation planning, further supporting the necessity of Equitable Transportation Planning. The research proposes and test several methodological approaches to evaluating equity considerations, including demographics analyses and equity evaluations that have theoretical grounding. A final contribution of this research is a set of formal procedures that can be used to incorporate transportation planning for equity into the greater performance management framework for long-range transportation planning.

1.5 Organization of Dissertation

The research in this dissertation follows the framework presented in Figure 1. The dissertation looks at four areas of literature to develop the concept of Equitable Transportation Planning and then identifies implementable analysis processes for transportation planning. The literature is supported by four case studies of MPOs that explore the metropolitan planning process and equity evaluation processes. The various analysis processes are applied and then compared to explore limitations in applying the values of Equitable Transportation Planning. These limitations are used to develop a set of methodological and planning recommendations to support planning for equitable outcomes. This document is organized as follows. The Literature Review is presented in Chapter 2 providing a background and motivation for the research, identifying the gaps and outlining the framing of the subsequent research. Chapter 3 discusses the methodology specifically detailing the analytical comparison of methods and its three components: demographic analysis, impact assessment, and equity evaluation. Chapter 4

presents the results of four case studies. The planning and equity evaluation processes for these MPOs is highlighted for their potential to apply Equitable Transportation Planning values. Chapter 5 presents the results of applying processes that were taken from the literature and practice and proposed methods based on the Equitable Transportation Planning concept to the case study of ARC. Chapter 6 presents findings about the ARC planning and equity evaluation processes and draws conclusions about the application of the findings from Chapter 5. Chapter 7 develops formal procedures for the formal integration of equity considerations identified in the previous chapters into the long-range planning process. The final chapter concludes the dissertation, highlighting the gaps addressed, study contributions, and articulating areas for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature relevant to how equity considerations can be integrated into the regional planning process. It begins with an exploration of equity theory, defining equity and developing a framework to classify different types of equity, and finally identifying an appropriate definition of equity for the context of achieving equity in the provision of transportation as a public good. The literature review then explores the goal of transportation equity within the frames of environmental justice and sustainability in order to explain the perspectives through which the concept of equity has been viewed in transportation. The review of sustainability determines how equity is established within goal setting and analyzed for sustainable transportation planning. The literature on environmental justice and transportation examines the analytical frameworks currently used in addressing equity in transportation through environmental justice assessments and identifies gaps and needs to develop analytical frameworks for equitable transportation planning at a system-wide level, including the assessment of cumulative impacts. Next the review examines the role and process of regional planning for metropolitan planning organizations and discusses the rise of performance-based planning and performance management, noting its current status in regional transportation planning. This chapter highlights the themes that connect equity theory, sustainability, environmental justice and performance management principles. It consolidates equity theory with transportation equity in practice and identifies the gaps in the literature between the two areas. It then positions the subsequent research within the metropolitan long-range planning process to establish values for Equitable Transportation Planning, that is, transportation planning that explicitly includes the goal of achieving

equitable outcomes for all that are served by the system. These values drive the research, which develops and applies qualitative and quantitative analysis to highlight and address the current limitations to achieving transportation planning for equitable outcomes at a system-wide level.

2.2 Defining Equity

To achieve equitable outcomes from transportation planning requires an understanding of what equitable outcomes are. For this, a fundamental understanding of equity theory is necessary. Defining equity is an endeavor that has been undertaken by philosophers, social scientists, politicians, and societies worldwide and throughout history. By reviewing the various meanings and related theories of equity, it is clear that equity is a pluralistic concept. Yet at the core of all definitions of equity is the idea of "fairness." One can attempt to define equity simply as the fair treatment of all, or justice. The question, however, then arises, "what exactly is fair?" This is where definitions vary.

Equity theory, presented in the literature in the fields of behavioral science and in economics, does not refer to some moral or ethical standard of equity. It reflects what a society regards an appropriate, fair or just distribution of goods and outcomes for its members based on needs and contributions. Young (1994) differentiates between a social order that is regarded as just and the just distribution of goods. In this way, the concept of justice may be viewed as composed of two concepts: social justice and distributive justice (Young 1994). Social justice represents the perception of just treatment. Distributive justice relates to the distribution goods in a just manner.

Miller (1992) posits three elements play into the judgment of equity: equality, deserts, and needs. These three criteria can be used to evaluate social justice (Khisty 1996). Equality suggests that all people in a society are equal and should be treated equally. Equality is at the base of the understanding of equity in the United States. At the birth of the United States, it was proclaimed that all men were created equal and had

certain unalienable rights. Rights are derived from laws, rules, and other publicly established standards for conduct. Equality asserts that each individual has the same rights, is subject to the same rules and has the opportunity to receive the same amount of a certain good, namely public goods, and therefore, in theory, subsumes that individuals are treated equally.

Contrasting with the equality criterion are needs and deserts. Needs relate to the ability or lack thereof in obtaining goods and deserts are measured by an individual's capabilities, virtue, and contributions (Miller 1992, Kristy 1996). Equality could suggest an equal distribution regardless of the ability of an individual (or population) to obtain a good or the inputs of said individual (or population). In actuality, there are stratifications of advantage and as a result, equal distribution of goods may not be judged as just. This is the case in addressing historic inequality. The equality criterion alone does not account for stratification of advantages. Applying the needs criterion and the equality criterion in concert would improve the perception of justice in cases with historic inequality.

The deserts (or merits) criterion can be examined in an integrated manner with the equality criterion as well. Equity theory in behavioral science defines a perceived equitable relationship as one where all participants receive proportional outcomes relative to their inputs (Walster 1978). Counter to this understanding, the equality criterion suggests the equal distribution of a good, regardless of contributions, which may be viewed as unjust. The deserts criterion suggests that the appropriate distribution is not necessarily an equal distribution but one based on the input of an individual or population.

Additionally, there is a clear conflict between the criteria of needs and deserts. The needs criterion bases goods distribution on some minimum level of return for all concerned and deserts bases goods distribution on the level of contribution towards the return. A balance between these two criteria is especially important in the case of historic biases that may affect the ability of an individual or population to contribute towards the

return. Social justice balances the needs and deserts of an individual along with the goal to provide an equal distribution in order to establish what can be considered a just social order and fair distribution of goods. Figure 2 visually describes the concept of justice, from the viewpoints of social justice and its three criteria and distributive justice and several potentially just distributions.

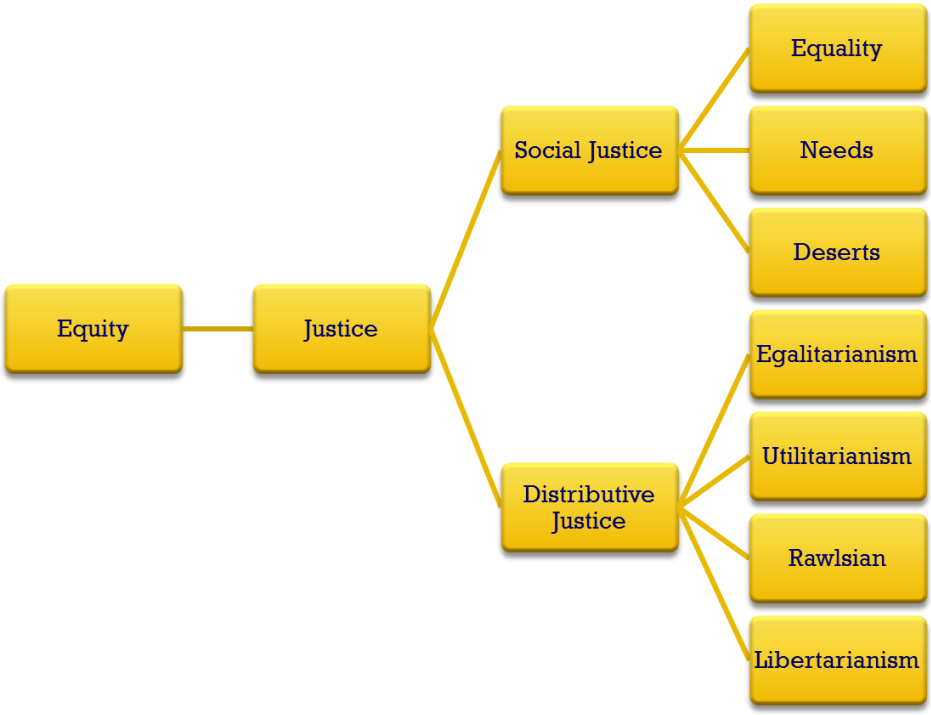


Figure 2 Defining equity through the concept of justice. Note how justice is broken into two components that are then further dissected.

What emerges from this review is that not all distributions under the broad umbrella of equity theory will be appropriate in assuring equitable outcomes in all contexts in space and time. The elements of social justice refer to outcomes. They do not apply to procedural, or distributive, justice. In the context of developing public infrastructure, such as a transportation system, equity must be relevant from an outcomes standpoint, that is, the outcomes of investment in the system must be equitable for the communities they serve. The criteria of social justice can therefore be used as a frame to understand theories of distributive justice used to provide equitable distributions. The

distributions may be seen as a way to achieve perceived social justice through the fair distribution of goods. The following will briefly discuss several distributions: egalitarian, libertarian, utilitarian and Rawlsian and their relationships to the social justice criteria.

Egalitarian distribution is based on the doctrine that all humans are equal (Merriam-Webster), and in this way, an equal distribution of goods is appropriate. Given the three criteria for understanding social justice, egalitarianism is overly concentrated on the equality criterion and does not incorporate and balance the other two: needs and deserts. Libertarianism is based on self-ownership and acceptance that the "invisible hand" of the market best decides the distribution of goods (Merriam-Webster, Smith 1776). The market distributes goods, which most greatly benefits those who invest most heavily in the market. Libertarianism essentially focuses on the deserts criterion in its approach to social justice. This does not incorporate and balance the equality or the needs criterion. Utilitarianism seeks to provide the greatest utility to the greatest portion of the population; the greatest good for the greatest amount of people (Merriam-Webster) and is an elementary construction for the distribution of public goods in urban planning (Taylor 1998). Utilitarian distributions can be approached in two ways. A Pareto approach is based on the condition that an improvement is acceptable if at least one person is benefitted and no one is disadvantaged. A Kaldor-Hicks approach considers a condition acceptable if some experience an improvement and the benefits are enough to compensate those disadvantaged. This does not mean that they actually are compensated (Coleman 1980). Utilitarianism implies some balance between the criteria. Essentially, the average benefit should be maximized. This suggests that there is not necessarily an equal distribution but there is a distribution of benefits across the population. The needs criterion is slightly accounted for in the Pareto approach by assuring no one's situation is decreased but it does not account for the level of need of those receiving benefits. Although there are not proportional returns, contributions in utilitarian distributions

increase the general welfare by increasing the average benefits, addressing in part the deserts criterion.

An additional distribution is derived from the work of Rawls (1971) in political science. Rawlsian distribution seeks to minimize the differences between the haves and have-nots by maximizing the minimum benefit. John Rawls's "A Theory of Justice" (1971) states,

"Each person possesses an inviolability founded on justice that even the welfare of the society as a whole cannot override. For this reason justice denies that the loss of freedom for some is made right by the greater good shared by others. It does not allow that the sacrifices imposed on a few are outweighed by the larger sum of advantages enjoyed by many. Therefore in a just society the liberties of equal citizenship are taken as settled; the rights secured by justice are not subject to political bargaining or to the calculus of social interest."

Criticizing the basis of utilitarianism, Rawls's argument suggests an importance in identifying marginalized populations and determining how they are impacted by decisions for society. As mentioned earlier, the United States was founded on the ideal that all men should be treated equally (in matters related to life, liberty, and the pursuit of happiness); however, over the history of the country, there have been historic inequities that have led various demographic groups to be marginalized. As a result, to address this historic disadvantage, legislation and regulations have been adopted on federal and local levels that are reviewed later. The country's understanding of marginalization, documented in legislature, highlights a preference towards the needs criterion in what this society regards as an appropriate, fair, or just distribution of goods and outcomes. Rawlsian distributions favor the needs criterion. Rawls's difference principle, also called maximin, is an approach to distributions that seeks to benefit the general population; however, it prioritizes expected benefit for the least advantaged (Rawls 1971), focusing particularly on the needs criterion.

Despite the departure from utilitarianism, Rawlsian distribution principles are similar in attempting to increase the average benefit. Martens (2012) highlights four distributions for transportation benefits all of which strive to increase the average benefit. In addition to a utilitarian approach, Martens (2012) discusses the other three distributions based on Rawlsian principles: (1) maximin, (2) maximizing the average with a minimum "floor" constraint, and (3) maximizing the average with a range constraint, which he calls maximax. In maximax, the average benefit is maximized while constraining the maximum gap between the most advantaged and the least. This improves upon the distribution by suggesting a continually increasing average and imposing a dynamic floor constraint based on the greatest benefit.

Figure 3 graphically depicts the relationship between the distributions and the three criteria for social justice. The three axes represent the social justice criteria and the various forms of distributive justice are labeled in boxes and placed relative to each other and the criteria. As discussed previously, egalitarian distributions align most closely to the equality criterion, libertarian with deserts and maximin with the needs criterion. The utilitarian distributions address the needs criterion differently. The Kaldor-Hicks approach does not account for any individuals that are disadvantaged where the Pareto approach ensures no one becomes more disadvantaged. The Rawlsian distributions approach the needs criterion to a greater level, ensuring the least advantaged receive benefits. The floor constraint sets a minimum threshold and maximax sets the minimum constraint based on the maximum returns to the system. Maximax reflects the needs criterion to a higher level than the floor constraint by focusing on allocating benefits to the disadvantaged relative to overall system benefits. Maximax also reflects the equality criterion by limiting the variance of the distribution between the greatest and least advantaged. Pareto, Kaldor-Hicks and the floor constraint reflect the equality criterion at a similar level because of their general increase in the average benefits. Because maximax has a maximum range, the minimum benefit is constrained by the greatest

benefit that is received. Similarly, the maximum benefit is constrained by the minimum benefit and therefore the range constraint can necessitate a distribution of goods based on need with less focus on the deserts criteria.

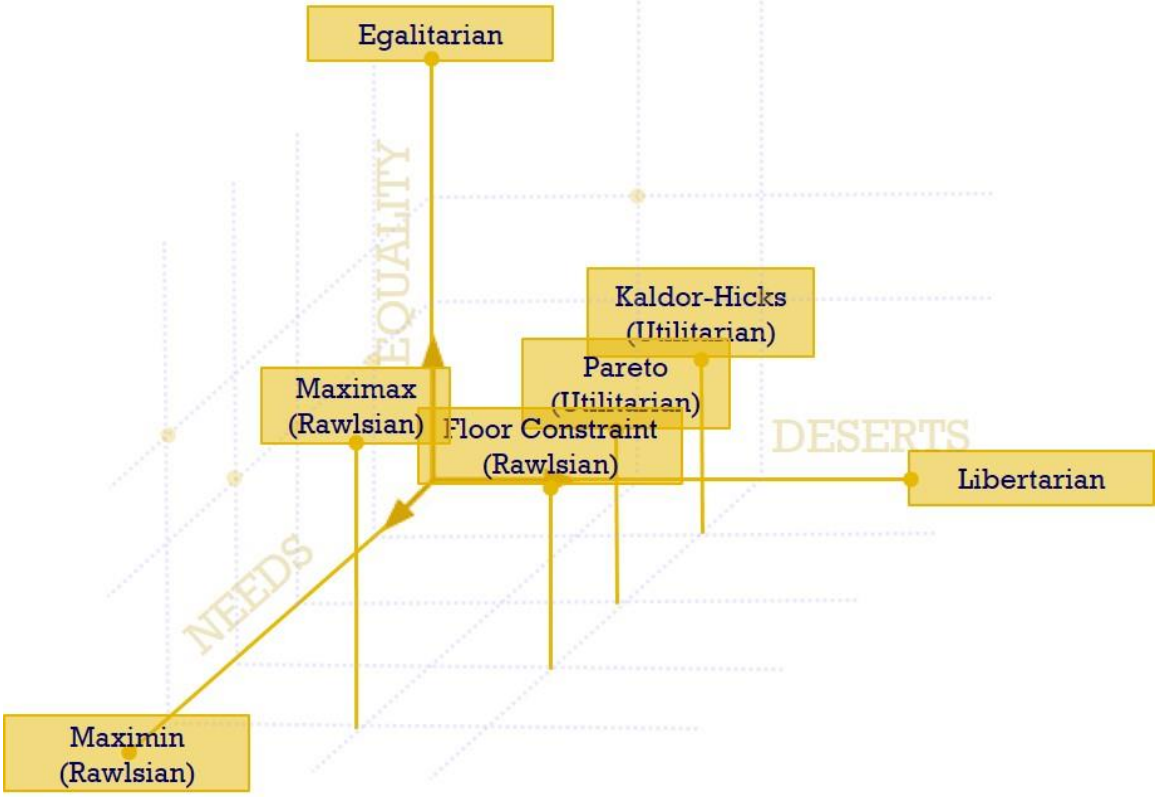


Figure 3 Types of distributive justice graphed in relation to the social justice criteria.

Transportation can be viewed as a public good, which is discussed further later in this chapter. As such, providing equal opportunity to benefits from the system is encouraged by equity theory, and required by law. There is also legal backing to ensure disadvantaged groups receive benefits from the transportation system, which is also discussed further later in the chapter. Given the Rawlsian maximax distribution's ability to balance the social justice criterion with sensitivity to the needs and equality criterion, it provides a suitable distribution for the context of transportation benefits by accounting for disadvantage while improving the average benefit of a public good.

It is important to note that although in theory it is assumed that distribution leads to a reflective outcome, equitable distribution may not lead to equitable outcomes. For example, an egalitarian distribution of transportation funding does not necessarily lead to an outcome where everyone has the same system results, even if the funds are invested in the same manner. The disconnection between distribution and outcomes leads to two concepts: equality of opportunity and equity of outcome. Equality of opportunity is related to procedural equity and equity of outcomes is related to the social perception of equity. These are discussed further in subsequent sections.

In transportation planning practice equity is often framed in two ways, either within environmental justice or as a component of sustainability. The following sections explore equity in transportation.

2.3 Sustainability and Equity

Sustainability is rooted in the environmental movements of the late 20th century, but over time has developed into a concept that focuses not only on environmental stewardship but requires the balance of three principles. Sustainability must account for not just environmental concerns, but also economic and societal concerns. The American Society of Civil Engineers (2009) defines sustainability as "a set of environmental, economic and social conditions in which all of society has the capacity and opportunity to maintain and improve its quality of life indefinitely without degrading the quantity, quality or availability of natural, economic, and social resources." This triple bottom line is widely accepted within Civil Engineering as well as other industries. There are, however, tensions in the interactions of each of the three types of capital (environmental, economic, and societal). Resource conflicts arise between environmental and economic values and societal tensions present complex issues. In balancing economic and social values, the conflict between economic growth and equity present the "property conflict" over the possession and use of property (Campbell 1996). Environmental concerns

valued in a social frame create the "development conflict" and the potential of limiting resources (Campbell 1996). The complex tensions among the three principles may lead to one or more of the three components to be under addressed. This is especially true in the case of the social component.

Social sustainability is a condition preserving and enhancing the well-being of communities over generations. Social sustainability is further explained through several related concepts including social inclusion, participatory democracy, and social capital and cohesion. Many of the concepts of social sustainability, including those mentioned, relate closely or tangentially with the idea of equity. In fact, the term "equity" may be referred to among the 3 E's of sustainability (environment, economy, equity). In this way, equity is a defining concept for social sustainability and significant for a comprehensive approach to sustainability.

Sustainability is increasingly found in the goals of transportation agencies across the country. In 2010, 40 percent of state departments of transportation included sustainability either explicitly or implicitly in their mission statements; however, few transportation agencies that have formally incorporated sustainability into their planning (i.e. long-rang plans and transportation improvement programs) have also incorporated the comprehensive approach based on the triple bottom line (Jeon and Amekudzi 2010). Past studies show an absence of societal values evident in limited inclusion of equity principles in sustainability practices (Agyeman & Evans 2003); however, Pearsall and Pierce (2010) suggests that there is increasing awareness of the need to incorporate social factors, especially equity, into sustainability considerations in transportation planning.

A complicating issue in including social factors is measuring them. A comprehensive review of rating systems designed to quantify levels of sustainability for transportation systems showed that rating criteria relating to social sustainability outcomes are limited, especially as compared with criteria relating to environmental or economic sustainability (Brodie et al. 2013). Table 1 illustrates this imbalance. It shows

eight sustainability rating systems for transportation (at the top of the table). Along the y-axis are a set of general categories for criteria that were distilled from a detailed survey. The categories are grouped into one of three types of sustainability criteria: environmental, economic, or social. If a rating system has criteria related to a category, this is indicated with a shaded box. The table also shows that specifically relating to equity, half of the systems did not have rating criteria, and of those that did, the measures related to public participation and not equity of resources or outcomes (Brodie et al. 2013). These results are indicative of the role of social factors in evaluating sustainability, supporting findings in the literature that social factors are often not weighted equally relative to environmental and economic factors. Manaugh et al. (2015) suggested that one reason for this is the difficulty in measuring intangible social sustainability factors. This then leads to prioritization of more quantifiable objectives.

Table 1: Comparison of Sustainability Rating Criteria for Transportation Systems

		Transportation							
	Criteria Categories	Greenroads	GreenLITES	STARS	BE^{2}ST	Green Pave	I-LAST	INVEST	EnvISIon
Environmental Sustatinability	Water Conservation	■	■	■	■		■	■	■
	Energy Conservation	■	■	■	■	■	■	■	■
	Environmental/Ecosystem Protection	■	■	■			■	■	■
	Climate Change		■	■	■	■			■
	Waste and Materials Management	■	■	■	■	■		■	■
	Noise/Light Pollution	■	■		■	■	■	■	■
	Sustainable Land Use	■	■				■	■	■
Economic Sustainability	Innovation/ Design		■	■		■	■	■	■
	Operations and Maintenance	■		■				■	■
	Cost Effectiveness	■		■	■			■	■
	Affordability	■		■	■				■
	Economy/Jobs								
	Transportation Impact	■	■	■	■	■	■	■	■
Social Sustainability	Access	■						■	■
	Safety	■						■	
	Equity/Inclusion	■		■	■				■
	Health/Well-being								
	Culture/Place-making	■		■	■				■
	Food Sustainability								
	Indoor Environment								

It is concluded from the literature that social sustainability factors, specifically equity, are underrepresented in sustainability in practice. If equity and other social factors are identified by the ASCE as definitive components of sustainability, they must then be included in sustainable practices and the decision-making process for sustainable

transportation. Johnson and White (2010) found that by not including social sustainability concerns with other transportation concerns in planning, they were also not included in decision making for funding allocations. As transportation agencies continue to identify sustainability as a goal, equity must be formally included as a transportation planning goal for a comprehensive approach to sustainable decision making.

2.4 Equity in Transportation Practice

Equity can be situated as a planning goal in the context of sustainability but considerations for equity are also stipulated by federal requirements. Equity is most commonly addressed in transportation through the lens of environmental justice. Environmental justice is defined as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income" in relation to the development, implementation, and enforcement of regulations and policies (EPA n.d.). The environmental justice movement emerged in the early 1980s and resulted in Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. Signed in 1994, it explicitly states that all federally funded programs must develop policies and procedures to achieve environmental justice. This executive order mandated the development of environmental justice regulations in all federal agencies, including the Department of Transportation (USDOT). Legal standing for this executive order is provided by Title VI of the 1964 Civil Rights Act that similarly stipulates nondiscrimination in all policy areas.

Minority and low-income populations are identified in Executive Order 12898 because prior disenfranchisement and resource limitations have led to their marginalization. Especially in the case of low-income populations, they may not have the political capital to impact the planning process without such interventions. The USDOT further defines minority to include: Black, Hispanic, Asian, American Indian and Alaskan Native, and Native Hawaiian or Other Pacific Islander (USDOT 2012).

Low-income is defined as households at or below the thresholds for poverty as provided by the guidelines of the Department of Health and Human Services (USDOT 2012). Transportation agencies therefore include, at a minimum, these groups of people in their environmental justice and equity analyses. Although the elderly, disabled and child population groups are not explicitly addressed in the environmental justice regulations, these populations are also often considered in practice (FHWA n.d.a, Cambridge 2002). Other groups that have been considered include residents with limited English proficiency, zero-car households, female-head households, adults without high school diplomas, and foreign-born residents.

The transportation community outlined specific goals and regulations for environmental justice in the late 1990s and updated them in 2012. The USDOT issued Order 5610.2 in 1997 and a revision, Order 5610.2(a) in 2012. Following both Orders, the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) issued more specific details for regulating and monitoring transportation activities. The original Order and its revision are based on three fundamental guiding principles (USDOT 2012):

1) To avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations.

2) To ensure the full and fair participation by all potentially affected communities in the transportation decision-making process.

3) To prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority and low-income populations.

These three principles account for disproportionate burdens, inclusive participation, and equitable receipt of benefits. These three components reflect procedural and outcome equity (Figure 4), two concepts that were mentioned briefly in the prior section on equity theory. Full and fair participation in the decision-making

process relates to procedural equity. Incorporating input from various populations, especially those with less political influence, into the planning process addresses equality in the process, or the procedures. The burdens and benefits are the results of the transportation improvements that are implemented based on the planning process. The distribution of these results relates to outcome equity.

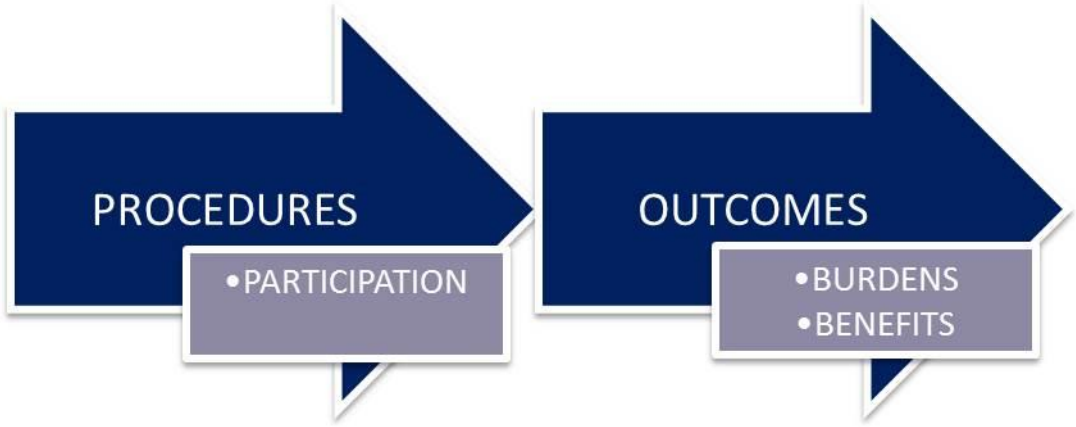


Figure 4 Illustration of environmental justice definition for transportation in terms of procedural and outcome equity

Procedural equity addresses equity in the planning process. The primary way to produce equity in the decision-making process is to incorporate all stakeholders, especially those who are marginalized, into the process. Attempts towards procedural equity were initiated in the 1950s by holding public hearings during or after the transportation planning process to inform communities about projects. ISTEA in 1991 introduced a federal mandate to incorporate public participation in the planning process. Over the last three decades, public involvement has evolved to better utilize public feedback in planning. Public involvement is the focus of many environmental justice programs in transportation (Forkenbrock 2004) and, as mentioned previously, procedural equity is the primary way that equity is measured in sustainability rating systems (Brodie et al. 2013). Although procedural equity influences the eventual outcomes, it does not necessarily result in equitable outcomes (Jerome and Donahue 2002).

Evaluating outcome equity necessitates a method for analyzing the results of transportation improvements. The nature of transportation projects is such that their impacts will not be equivalent to all people; there will be distributive effects. Distributive effects are quantifiable results that have differing effects spatially, temporally, and across social groups (Forkenbrock 2004). The effects of transportation improvements will also be cumulative, building upon each other over time. Cumulative impacts are defined by the Council of Environmental Quality (CEQ) as the resulting effect on the environment from incremental impacts that are added to other past, present or reasonably foreseeable future actions (CFR 2012, FHWA n.d.b). The CEQ, through the National Environmental Policy Act (NEPA) process, establishes that all Federal agencies, including USDOT, have the responsibility of addressing cumulative impacts. Emphasis has been placed on ecological resources and effects on resources such as air quality and wetlands are often analyzed. There is less focus on socioeconomic effects (Scammell et al. 2014); yet, cumulative impacts also refer to the total effect on a human community due to past, present or future activities or actions (FHWA n.d.b).

Distributive effects and cumulative impacts comprise both the burdens and benefits that result from transportation projects. Common practice focused on the distribution and mitigation of burdens, but it is necessary to assess the net distributive effect by weighing burdens against the benefits of projects (Cambridge 2002). Similarly, cumulative impact analysis has a greater focus on negative impacts (Scammell et al. 2014). Trends in practice show that benefits of transportation improvements, especially accessibility, are being considered more often. The net effect of burdens and benefits should be evaluated cumulatively, over the system and over time (Amekudzi, Smith, et al. 2012, FHWA 2015a) to achieve the desirable results, which are distributive effects that are equitable, but not necessarily equal, across various segments of the population. This dissertation applies the CEQ definition of cumulative impacts, focusing on how the human community of a region experiences the transportation system as a result of

improvements, projects and other actions over time. This experience is characterized by the transportation system benefit of accessibility, which results from the total effect of past and present transportation projects and policies. Although this research focuses on accessibility, there is an opportunity to apply this methodology similarly to impacts such as safety, air quality, or specific transportation-related health impacts.

As explained in the section on equity theory, equitable impacts of transportation improvements are decided by what society, including various stakeholders and the public, perceives as just based on balancing the three criteria of social justice for the context of transportation: equality, needs and deserts. Examining equity for distributive impacts obligates that system-wide and cumulative outcomes of projects are monitored and the resulting information is fed into decision making to ensure an equitable system is developed over time. Quantitative analysis of environmental justice outcomes is most often used by transportation agencies in environmental justice and equity analyses. It estimates the distribution of impacts across the population, especially across the target populations and attempts to measure distributive effects; however, it has limitations in capturing cumulative impacts.

Quantitative analysis of environmental justice outcomes, based on the literature, can be organized into three steps: identification of the population and study area that will be impacted, determination of the impacts resulting from the transportation improvement, and an analysis of the distributive effects for disproportionality (Figure 15).

Figure 5 Existing framework for quantitative analysis of environmental justice outcomes

The quantitative analysis procedure was based on processes used early in the environmental justice movement to determine the effects from point sources such as landfills and other locally unwanted land uses (LULUs) (Chakraborty 2006). This procedure can be useful for transportation impacts that are spatially concentrated, such as emissions and noise, which emanate directly from a transportation facility and directly impact populations adjacent to it. It is most applicable for project-level evaluations and as such, the quantitative analysis procedure is usually applied at the project level. At Departments of Transportation (DOTs), in fact, environmental justice analyses typically evaluate project-level impacts (Amekudzi, Smith, et al. 2012). MPOs, however, generally do not evaluate individual projects, instead they evaluate the total program of projects and assess regional impacts. For regional impacts that are spatially constrained, the three step process may be applicable. Regional cumulative impacts such as accessibility, however, do not originate at a single source but rather result from the aggregate of projects in the overall network. It is most useful to approach these impacts at a macro, regional level. Furthermore, long-range plans should integrate environmental justice in key decisions (FHWA 2015a), for which the three step quantitative analysis is even less applicable. The quantitative analysis procedure has been used for regional impact assessments; however, because it was developed for the evaluation at the project level it fails to fully evaluate cumulative impacts, limiting the effectiveness of its application for regional long-range planning. The following section discusses the quantitative analysis of environmental justice outcomes in detail and highlights the limitations for capturing regional, cumulative outcomes.

2.4.1 Note on Scale of Analysis

Before beginning the discussion on quantitative analysis procedures, it is important to make a note about the scale of the analysis. The geographic unit of analysis can have a substantial impact on the results of environmental justice assessments.

Impacts and populations can be viewed at a geopolitical level, such as the county, city or neighborhood, census divisions, such as tract, block group or block levels, or at other geographic units, such as traffic analysis zones. Dramatically different results can occur when evaluating impacts on populations using different geographic units. This is evidenced in studies evaluating the correlation between the siting of hazardous facilities and minority populations. While some such studies have found negative correlation between the location of hazardous facilities and minority populations, others found a positive correlation. This contradiction is likely because of the geographic unit used in each evaluation. A study in Allegheny County, PA found that by altering the unit of analysis, the correlation between location of facilities and minority population changed. Using Census block groups, the study found that the proportion of minorities around hazardous facilities was lower than the proportion of minorities in other communities. However, the proportion of minorities within a half-mile radius of the sites is larger than those outside this area (Maantay 2002).

Census data, and most other demographic data, does not account for densities within the unit of analysis. Instead they impose a continuous artificial spatial distribution of information across a geographic area and in effect, produce artificial spatial patterns. This is known as the Modifiable Areal Unit Problem (MAUP). The aggregation of data reduces the reliability of results (Maantay 2002). Because of the aggregation of data, the MAUP hinders acquiring accurate spatial representations of data (Duthie 2007). This artificial distribution leads to varying results at different levels of geographic units. The aggregation of data hinders high resolution applications and renders evaluations of impacts at highly aggregated levels almost meaningless because of the variation of demographics in the larger units of analysis. A similar issue arises in applying statistical correlations across varying scales of resolution (Amekudzi and Dixon 2001).

The ideal unit of analysis is small enough to contain fairly homogenous population demographics (Forkenbrock 1997). Census tracts provide a group with

similar demographic and socioeconomic characteristics, however, they still contain approximately 3,000 people and maybe spatially large. The census block group and census block are therefore the most attractive options; however, less data is available and economic household information is not provided at these higher resolutions (Forkenbrock 1997). Although the census tract is not the highest possible resolution, it still provides a small population relative to a metropolitan region that shares some general characteristics. Additionally, it provides a substantial amount of information not found at higher resolutions and therefore is the most appropriate spatial unit for regional demographic analyses for equity evaluations.

2.4.2 Quantitative Analysis of Environmental Justice Outcomes

The first step outlined in the quantitative analysis of environmental justice outcomes defines the population and study area. As discussed previously, the target population can be defined in several ways, based on minority and low-income populations at the minimum. The quantitative analysis procedure also requires that a reference population is defined to which the outcomes for the target populations are compared. Because there is no clearly defined procedure for determining a reference population, the reference population can range from an aggregation of residents in a regional area to a limited population of the census units contained within a study area (Most 2004). This flexibility presents a challenge because the impacts on the target population will be compared to the impacts on the reference population to determine disproportionality; therefore the definition of the reference population has great implications for the analysis.

In regional analyses, common practice is to define target areas based on a demographic analysis. Upon determining what socioeconomic factors will define the target populations, a demographic analysis is conducted to locate areas in the region with high concentrations of target populations. Target populations are represented spatially by

census tracts or traffic analysis zones (TAZ) with target populations above a certain limit. These thresholds are discussed later in this section. The reference population is most often considered the census tracts or TAZs that are not defined as target areas.

The standard quantitative analysis of environmental justice outcomes identifies target populations as a first step. It focuses the lens on a subset of citizens to account for historical marginalization. This process limits the scope of the analysis. It removes robustness from the evaluation and has potential to create dissention among decision makers, especially in determining who should be included in the definition of target populations or the designation of target areas. As evidenced in legislature, accounting for historical marginalization is necessary, but in determining whether there is current marginalization, there will be value in broadening the evaluation in scope to identify general patterns of inequity, especially when evaluating cumulative and regional impacts. Furthermore, applying the maximax distribution to explain equity theoretically requires an improvement in the average benefit for the whole population and this cannot be evaluated with a focus solely on target populations.

The first step of the analysis also defines a study area. For micro-level evaluations, this is done to determine the population that will experience impacts due to a specific improvement. For regional impacts and network-based outcomes, the entire region becomes the study area.

The second step is to identify the impacts of concern. The outcomes of transportation projects, programs, or policies provide benefits or may result in burdens to the general population. As one can imagine, there is a plethora of possible outcomes and impacts. Transportation user effects are important indicators of environmental justice (Forkenbrock 2004) and correlate with cumulative impacts. They are the result of an accumulation of transportation improvements over time. These user effects are also captured by transportation system priorities such as mobility, safety, economic development, health and accessibility. Depending on the impact that is being evaluated,

the quantitative analysis for environmental justice may be more or less equipped to evaluate it.

This research focuses on accessibility, or the ease with which people can reach a desired destination. This ease is a function of the location of destinations and the transportation network, including multi-modal options, available to reach these destinations (Litman 2011). As mentioned, accessibility is the result of cumulative transportation improvements over time. Accessibility to critical services, jobs, schools, and other daily necessities are basic needs. Accessibility to parks, libraries and cultural institutions allow populations to participate in society. Drawing upon the DOT Order and an understanding of transportation as a public good and equity, all segments of the population should have equitable access to these opportunities. Disparate accessibility to such destinations across various portions of the general population, and over different periods of time can be viewed as an inequitable outcome of cumulative transportation investments and can exclude certain populations from basic needs and transportation benefits. This dissertation uses this criterion to distinguish between equitable and inequitable transportation systems, that is, an equitable transportation system is one that offers the communities it serves equitable access to the benefits and burdens of the system.

In addition to social impacts, differences in accessibility can have economic and political repercussions (Bohon 2008). It has been argued that jobs in low-income communities are low-paying low-skill jobs with limited opportunities for upward advancement (Bohon 2008) and limited accessibility makes these jobs the primary option for residents in these communities, making them captive workers in low-paying jobs. Other theories such as spatial and/or modal mismatch suggest that there is limited access between low-wage workers and skill appropriate jobs contributing to unemployment (Sanchez 2004, Grengs 2010). Despite the apparent differences in these two philosophies, they both center on the problem of limited accessibility for low-income

populations and the resulting economic burden. Property values are also impacted by accessibility (Geurs 2010) producing additional economic effects. Limitations for participating in the political process, including public meetings required by environmental justice policies, Title VI, and NEPA, can also result from reduced accessibility. In addition to physical projects, transportation policies that enable prohibitive costs of transportation or force reliance on automobiles also negatively affect accessibility. The accessibility difference between automobiles and public transit is especially relevant in regards to equity as much of the transit-captive population can be classified as marginalized.

The focus on accessibility in this research is based on recognition that transportation is a largely a derived good that derives its utility from reaching goods and services; reaching goods and services is the definition of accessibility. Evaluating accessibility, therefore evaluates the effectiveness of the transportation system. Accessibility has become more widely recognized as a critical issue with the sprawling, automobile-centric development of the American metropolitan areas and suburbs (Kawabata 2007) and as just outlined, has substantial impact on community quality of life. With the goal of providing equitable transportation service within a region, this measure of effectiveness is a reasonable point of departure. It also enables one to better evaluate the extent to which the transportation system enables a certain level of quality of life for all populations.

The final component of quantitative analysis of environmental justice outcomes is evaluating the impact for comparative differences between target populations and reference populations. In this step the level of impact is evaluated based on the population impacted in comparison to the reference population. Rational method indices and methods using fixed proportions and thresholds may be used to assess disproportionality.

Proportional indices are referred to as rational methods by Hartell (2007). These methods are similar to location quotients used in economic analyses and were developed for application in project-level analysis to measure the likelihood of overrepresentation of target populations in impacted areas adjacent to projects. Still, it is possible to adapt the methods for regional evaluation. Two of the rational methods are the Buffer Comparison Index (BCI) and the Area Comparison Index (ACI). The BCI measures whether the population within an impacted area has an overrepresentation of the target population in comparison to the larger geographic region (Chakraborty 2006). The following ratio of ratios is used to determine this:

$$BCI = \frac{\text{Target population in study area/Target population in reference area}}{\text{Non} - \text{target population in study area/Total non} - \text{target population in reference area}}$$

This index (as well as the others) compares an area impacted by a project to a larger reference area. In a regional comparison, this can be adapted where the study area is represented as spatial units affected by the impact and the reference area represents the entire region or the spatial units unaffected. For the BCI, the reference area would be represented by the entire region. As such, it compares the relationship between the target and non-target population that is impacted to the relationship of the two populations for the whole region:

$$BCI = \frac{\text{Target population in impacted area/Regional target population}}{\text{Non} - \text{target population in impacted area/Regional non} - \text{target population}}$$

An additional ratio, being offered by this work, can be constructed using the regional population unaffected by the impact as the reference population. This compares the ratio of populations (target and non-target) in the impacted area to that ratio outside the impacted area. It is referred to as the Population Comparison Index (PCI). It compares the populations in the impacted area to those in the reference area to test for overrepresentation:

$$PCI = \frac{\text{Target population in impacted area/Non} - \text{target population in impacted area}}{\text{Target population in unimpacted area/Non} - \text{target population in unimpacted area}}$$

The PCI is the result of enumerating the various combinations for comparing populations that are impacted and those that are not and for comparing target populations to a reference population. Most of these combinations do not provide applicable comparisons and while the PCI provides similar information to the BCI, it is more sensitive to difference between the target populations and the non-target populations. Essentially, any change in the population produces a greater percent change in this index as opposed to the BCI. This reflects the effects of using different reference populations in equity evaluations. Comparing the ratio of target population within and outside of the impacted area with the ratio of the non-target population within and outside of the impacted produces an equivalent result to the PCI. The PCI compares the demographic breakdown between the impacted area and the unimpacted area.

The Area Comparison Index (ACI) is the other index found in the literature. It also tests for overrepresentation in an impacted area. This method compares the target population within the impacted area to the target population in the reference area (Chakraborty 2006). The following ratio of ratios is used to determine this:

$$ACI = \frac{\text{Target population in impacted area/Total population in impacted area}}{\text{Target population in unimpacted area/Total population in unimpacted area}}$$

The ACI only focuses on the target population, which allows the comparison of target population within and outside the impacted area independent of other populations. It expresses the relationship between the target population affected and the target population unaffected. Using both the ACI and either the BCI or PCI in concert can provide insights on whether disproportionality is influenced by the population or the spatial distribution of the impact.

For all indices, if the index is greater than 1, there is an overrepresentation of the target population in the impacted area. These indices assume a goal of equality, that all populations experience the same level of impact. Based on the understanding of equity

theory and the need to balance the three criteria of social justice, this method is limited to evaluating along only one criterion.

Rational methods are useful for comparing impacts on a total target population. In using rational methods, it is not necessary to identify target areas; the indices can be applied to the actual population within and outside an impacted area. Although this presents an advantage, for impacts that are widespread or regional, it weakens the analysis because it does not account for the actual spatial location of target populations, just the percent of population in what may be a large area. Additionally, it reduces the impacts across an entire region to one point of numerical information. The results of rational methods can provide an idea of disproportionality, however, they do not tell the story of how the impact is distributed throughout the region.

Other methods used to determine disproportionality are based on fixed proportions. These methods are used to identify spatial units with disproportional concentrations of target populations. A comparison of impacts on these "target areas" and the reference area can be used to determine disproportionality. One such method is the plus-standard deviation method. The plus-standard deviation method calculates the percentage of the target population in each census tract (or other spatial unit) and compares this to the average target population of the larger region. If the percentage of target population is more than one standard deviation greater than the mean of the reference area, then the target population is overrepresented and the census tract can be defined as a part of the target area. This is an example of a threshold method. Another method based on predetermined proportions is the plus-25 percent method. This method establishes disproportionality by determining if the census tract has a target population 25% greater than the percentage of the target population in the regional population (Hartell 2007). Other simpler thresholds may be set also (e.g. 50% of the tract population is target population). Most often, regional impacts are evaluated using the threshold of the regional average; if the target population in a census tract is greater than the regional

average, the tract is part of the target area. Although these methods are most commonly used to define target areas in practice, they can also be used similarly to the rational methods to compare the demographic composition of the impacted area and the reference area.

The plus-standard deviation, plus-25 percent, regional averages, and other fixed proportion threshold methods have the potential to neglect small, highly concentrated, disadvantaged groups if they do not have enough influence on the larger tract. In addition, when comparing study areas, the results of these methods can be misleading. A small population containing a certain amount of disadvantaged households will have a percentage higher than a larger population with the same sized disadvantaged population. This can cause some disadvantaged populations to be neglected. Additionally, the focus on statistical cut points and measures of central tendencies can mask important information about the distributions of transportation impacts (Bills 2012). The change in distributions may have implications for equity that are not seen in the standard methods for analyzing disproportionality. Bills (2012) used results of an activity-based travel demand model and the development of synthetic populations to compare effects on the distribution of target population. Table 2 summarizes methods for determining disproportionality, with their advantages and disadvantages.

Table 2: Summary of Methods for Determining Disproportionality

Method	Advantages	Disadvantages
Rational Comparison (BCI, PCI & ACI)	• Flexible (ability to compare within study area or to outside area) • Based on area population and not arbitrary threshold; No target areas are defined • Simple mathematical calculations	• Highly sensitive to inaccuracies of data • No spatial context • Tests for equality alone
Standard Deviation	• Defined threshold relative to area population • Simple mathematical calculations	• Potential to neglect small highly concentrated disadvantaged groups • Mathematical logic could be

		difficult to explain to those without knowledge of basic statistics
Plus-25% and Fixed Proportions	• Defined threshold through use of fixed proportions • Easily comprehended by non-technical audience • Simple mathematical calculations	• Potential to neglect small highly concentrated disadvantaged groups • Least rigorous • Arbitrary threshold
Statistical Distribution	• Additional information on full spectrum of population	• Requires activity-based modeling • Based on synthetic population

Long range regional plans are subject to environmental justice stipulations and as such, the quantitative analysis framework has been applied to the planning process. The study area is identified as the regional planning area and the target population is represented by tracts (or other spatial units) that surpass a defined threshold of target population, such as the regional average (Karner and Niemeier 2013). The tracts that surpass the threshold are aggregated into a target area. The impact on the target area is evaluated through the regional travel demand model, either the base year output is compared to the forecasted output or forecasted build and no-build output is compared. Disproportionality may then be evaluated by determining if the change for the target population is comparable to the change for the reference population (Karner and Niemeier 2013). MPOs typically focus on this level of analysis rather than project-level analysis (Cambridge Systematics 2002).

There are limitations to the application of this framework to regional planning. First, although the quantitative analysis of environmental justice outcomes provides a tangible evaluation for equity regulations, it fails to evaluate equity as it has been described based on the theories of equity. It addresses the need to evaluate the circumstances of marginalized populations but does not take a holistic view of the population nor address overall regional improvements. Representing target populations

as tracts (or other geographic units) is problematic for target populations that do not congregate spatially (Duthie 2007). Representing the population in this way produces an ecological fallacy, meaning the characteristics or behaviors of a group of people are inferred from the characteristics of a spatial unit due to aggregation. For example, it has been shown that different racial groups within the same neighborhood may have greater travel behavior differences than between the spatial units defined to represent minority populations and those representing non-minority population (Karner and Niemeier 2013).

When the quantitative analysis is applied to regional planning it begins to capture the effect of the comprehensive transportation system. It expands the application of the process to regional, macro level impacts and in comparing base year and forecast year outputs, as is sometimes done, a temporal component is incorporated. Still, environmental justice analysis focuses on the central tendency of impacts. For example, the average accessibility for the target population is compared between a base scenario and a forecasted scenario. Or maybe the comparison is between the average accessibility of the target population and the reference population or between the average accessibility of several projected scenarios. All of these methods are used in practice. What remains the same in these cases is that the distribution of benefits across the population does not play an important role in the analysis; an increase in the average is suitable to establish equity. This focus on average values and measures of central tendencies can mask important information about the distributions of transportation impacts (Bills 2012).

2.5 Approaches to Incorporate Equity into Transportation Planning

As explained previously, equity is a pluralistic concept and therefore evaluating equity can be approached in many different ways. This research has defined equity as having two complementary components, social justice and distributive justice. Social justice explains the perception of equitable outcomes and distributive justice addresses the distribution of goods to influence equitable outcomes. This definition can describe

both equality of opportunity and equity of outcome, previously defined as procedural equity and outcome equity. Procedural equity focuses on an equal opportunity to produce a balance of rights, needs and deserts for all through the distribution of goods. Outcome equity concentrates on the substantive results of the distribution and how they may or may not be perceived as equitable based on a balance of rights, needs and deserts. Procedural and outcome equity work in concert to cultivate a process of goods distribution that produces an equitable perception by society based on the social justice criteria.

2.5.1 Procedural Equity Considerations

Procedural equity addresses equity in the planning process. It relates to the procedure that is used to determine what distribution of goods is just (or fair). By applying a just distribution, a region disseminates investments in order to produce an outcome that is deemed equitable. As discussed in the section on equity theory, a common distribution in fields of planning is utilitarianism. Here the average benefit for society is maximized; the outcomes are distributed to provide the most benefit to the greatest portion of the population. Transportation planning is generally governed by utilitarian principles through the frequent use of cost-benefit analysis (Khisty 1996). Cost-benefit analysis attempts to provide the most efficient use of funds by maximizing the average benefits compared to the costs. The distribution of the benefits across the population, however, is neglected. This exemplifies a limitation of the utilitarian distribution: the receipt of benefits is varied and some may receive no benefits or may be burdened. Approaches such as Rawlsian-based distributions as discussed by Martens (2012) strive to increase the average benefit yet highlight distributions for transportation benefits. Using criteria such as equity in addition to cost-benefit ratios in decision making can help address this limitation as well.

Procedural equity is generally approached by providing the opportunity for meaningful participation of all stakeholders in the decision-making process. This allows the needs, concerns and priorities of all parties to be incorporated into the process of planning, selecting, and implementing changes in the transportation system. It provides the platform for all stakeholders to influence the outcomes. Public involvement programs are a common tool used to facilitate procedural equity. These public involvement programs are federally mandated and furthermore, the involvement of marginalized populations in the planning process is required through the environmental justice executive order. A study by Shay et al. (2015) used public involvement within the quantitative environmental justice analysis to assist in identifying target areas and MPOs such as Boston Metropolitan Planning Organization's use of public involvement to determine which impacts and outcomes should be evaluated (BRMPO 2015a). Although there is no federal mandate, regional planning decisions that capture the variation of urban, suburban and rural priorities across the region and the complexity of interests across changing contexts of a metropolitan area to plan for all, have a better chance of producing an equitable transportation system. Procedural equity supports equitable outcomes across geographic and jurisdictional boundaries because it gives stakeholders across the region opportunities for getting involved in the planning process. Procedural equity considerations are addressed when decisions on investments for the transportation network are open to stakeholder input and public involvement as well as inter-jurisdictional coordination to influence the eventual transportation system outcomes.

Another procedural equity factor is to further incorporate equity into the planning process by using results of equity evaluations in programming. Although environmental justice policies and even environmental justice procedures may be formalized in policy, the meaningful incorporation of equity evaluation into the planning process is often lacking (Amekudzi, Smith, et al. 2012). Identifying equity as a priority applies influence at the goal setting phase. The case studies (Chapter 4) show that where equity was

identified as a planning goal, equity considerations influenced MPOs' decision making; however, few agencies use equity as a criterion for project prioritization and program evaluation. Although environmental justice is the primary vehicle for equity evaluation in transportation planning, the results of quantitative analyses for environmental justice outcomes are often not incorporated into the planning process (Amekudzi, Smith, et al. 2012).

The goal of equity and the goals and priorities of multiple stakeholders can be incorporated within the planning process through various paths of influence. Paths of influence towards transportation outcomes are illustrated using the transportation planning process in Figure 6 that depicts the basic transportation planning process modified to incorporate strategic and performance-based planning. Influence can be applied during strategic planning, resource allocation, the implementation phase, or in using the outcomes as feedback for further planning. Incorporating equity in the performance management process would in turn influence the development of the long-range plan and Transportation Improvement Program. In this way, equity considerations would be most effectively applied during the performance management cycle to ensure incorporation in decision making.

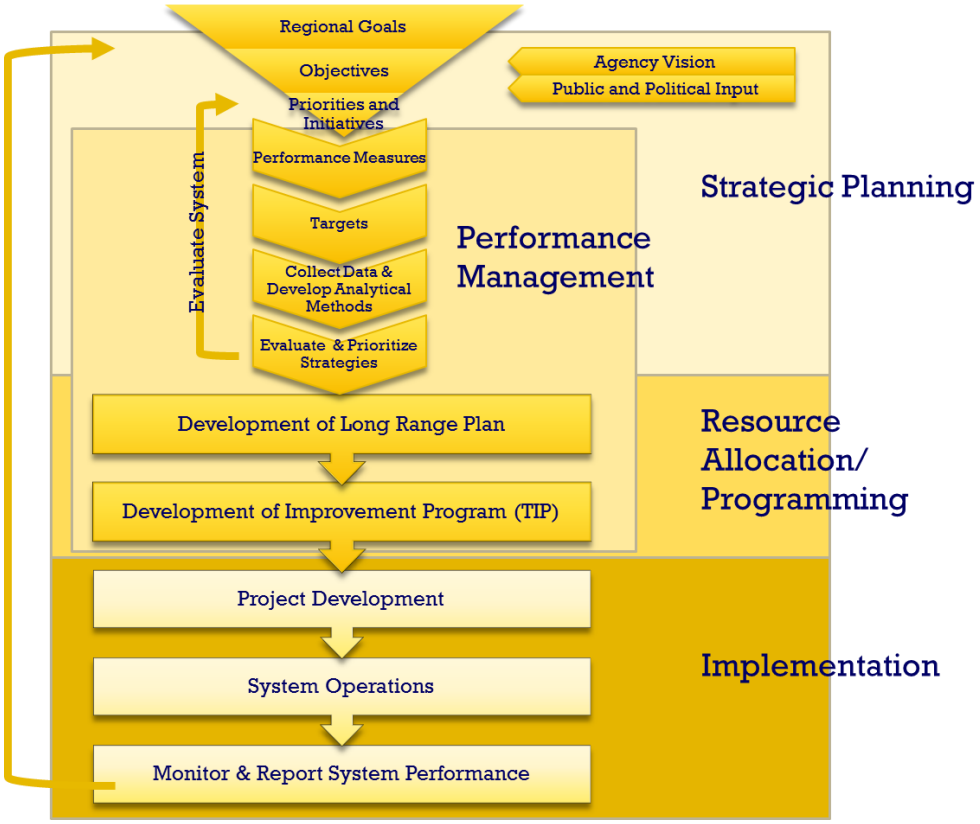


Figure 6 Metropolitan transportation planning process incorporating aspects of strategic planning and performance management. Formal procedures for equity considerations are also depicted within the process. (Adapted from FHWA 2007, Meyer and Miller 2001, FHWA 2014, Cambridge Systematics 2010, AASHTO 2006)

2.5.2 Outcome Equity Considerations

Although procedural equity influences the eventual outcomes, it does not necessarily result in equitable outcomes. Where procedural equity looks at equality of opportunities in the planning process, outcome equity evaluates the distributive effects of projects, plans, and policies to better understand the equity of outcomes. Impacts of transportation improvements (burdens or benefits) will be distributed spatially, temporally, and across the population (Forkenbrock 2004). The nature of the transportation network makes it unlikely that there will be equality of impacts; therefore, the goal of outcome equity is not as simple as producing equal outputs. Outcome equity

considerations can help find and understand gaps within the transportation system and aid in balancing the outcomes across the system.

In the metropolitan long-range planning process, the outcomes of the transportation network are generally estimated in the travel demand modeling process. The results of the model forecast outputs such as travel time and traffic volumes based on the input transportation network and planned projects to project future impacts such as air quality and accessibility. Outcomes from different investment scenarios can be compared and evaluated for equity based on equity theory distributions. Although there is no clear definition of, or standard for measuring equitable distribution of transportation outcomes (Martens et al. 2012), if equity is approached from the theoretical grounding in social justice, the outcomes should balance the three justice criteria to a point that can be perceived as equitable by a society (Miller 1992, Kristy 1996). As discussed in the section on equity theory, different distributions of goods balance the equity criteria differently. And as that section concluded, maximax distributions are applicable for the context of transportation impacts.

Based on the Rawlsian model, which encompasses maximax, there should be some minimum level of benefit experienced by the full population. It is expected that a transportation system meets some minimum level of accessibility for all travelers, allowing them to reach critical destinations. This ideal is rooted in transportation serving as a public good or defining it as a civic right. The concept is also visible in the mission of the USDOT and many other transportation agencies that explicitly express a goal for a safe and efficient system that meets the needs of all users (USDOT 2015). Failure to meet a minimum level of service for all users reflects failures in the system and suggests there are inequities present.

The minimum level of performance essentially functions as a floor constraint; however a simple floor constraint may not be helpful to highlighting gaps, that is, differences between the highest and lowest benefits being experienced across the system.

For example, if a floor constraint for transit access is defined by some regional accessibility target and that target is achieved overall, but some urban areas experience transit access at levels far higher than the constraint, then this approach does not capture the disparities between the lowest and highest levels of accessibility experienced by the community of users. Approaching equitable distribution of transportation benefits involves evaluating outcomes and the relative difference between them. In this way, it is not necessarily a floor constraint that is set but a range constraint across the distribution of outcomes. The maximax distribution is applicable as it imposes a dynamic floor constraint based on the greatest benefit, effectively creating a range constraint useful for understanding gaps in benefits. Golub and Martens (2014) propose methods for establishing a constraint on the range for the benefit of accessibility based on the maximax principle.

The average impact, the minimum standard, and the range of the distribution are thus important indicators of the distribution of an outcome. Although it is often practiced, focusing only on the average impact of an outcome neglects the wide range of impacts that may be felt by the population. A critical component of evaluating outcome equity is understanding the distribution of the outcome (Pearsall and Pierce 2010). Information on the distribution of impacts can help identify gaps in service between those that are greatly impacted and those that are not and transportation agencies can use this information in planning and project development/resource allocation decisions to influence equity of outcomes.

2.6 Performance Management for Long Range Planning in Metropolitan Planning Organizations

This research explores equity at the scale of regional planning, in the context of the greater metropolitan area. Metropolitan Planning Organizations (MPOs), in their capacity as coordinators of regional comprehensive transportation planning, are

continually in a cycle of developing and updating long-range plans that provide goals and accompanying strategies to support the transportation vision over the time horizon of 20 to 40 years. Metropolitan centers across the country identify various priorities for their regions, and federal legislature requires the production of a long-range plan to guide achievement of their goals in a comprehensive, coordinated and cooperative fashion (FHWA 2007).

In an effort to achieve these goals, transportation planning has become increasingly more performance-based. Federal legislature has encouraged efforts to evaluate projects, programs and policies based on performance since as far back as the early 1990s. The Government Performance and Results Act (GPRA) passed in 1993 encouraged performance-based decision making in all federal agencies and the GPRA Modernization Act of 2010 furthered the requirements to drive budget and policy decisions based on performance measures (Pew 2011). According to a December 2010 report by the U.S. Governmental Accountability Office (GAO) however, "only a select few states have made significant attempts to integrate performance measurement into their statewide planning process to inform investment decisions" (USGAO 2010). Specific to transportation, funding authorizations (ISTEA, TEA-21, and SAFETEA-LU) have included elements of performance-based decision making (Amekudzi, Fischer, et al. 2012). The 2012 authorization of the Federal Surface Transportation Program (MAP-21) incorporated a clear performance-based policy and programmatic framework for transportation investment.

MAP-21 funded surface transportation programs for the 2013 and 2014 fiscal years and formalized a performance-based approach in planning the growth and development of the nation's transportation infrastructure. The transformational aspect of the authorization is the performance- and outcomes-based program that introduced performance management to guide the achievement of national strategic goals. The transportation legislature mandated the development of performance measures and the

integration of these measures into the decision-making process through long-range planning. This research defines equitable outcomes within a performance-based planning framework. Performance-based long-range planning forecasts outcomes of programs and incorporates this information in the planning process. The distribution of these forecasted outcomes provides significant information for equity evaluations.

The performance management mandate was established in 2012; however, transportation agencies had been moving towards more performance-based decision making over the last few decades and were at different levels of maturity in their performance management programs (Bremmer 2005). Performance measurement has led to more mature performance management. Performance measurement determines how best to measure activities, processes and outcomes, and collects and analyzes the data to do so. It is "the ongoing monitoring and reporting of program accomplishments, particularly progress toward pre-established goals" (USGAO 1998) through the use of performance measures. FHWA defines performance measures as quantitative or qualitative indicators of system effectiveness and efficiency, including cost effectiveness (Otto and Ariartnam 2009).

Performance management, a term relatively new in the transportation context, goes beyond performance measurement by incorporating the results of tracking into decisions on project prioritization and resource allocation. The business practice of performance management can be adapted to the traditional activities of a transportation agency to produce a framework for data-driven decisions that achieve the outcomes important to the agency and its stakeholders. FHWA defines performance management for transportation as a strategic approach to achieve performance goals that uses system information to make decisions on investments and policies (FHWA 2015b). Figure 7 depicts key processes of performance management

Figure 7 The Performance Management Process (Amekudzi, Fischer, et al. 2012)

Performance measures are used to track progress towards goals. Common performance measures relate to traffic operations and physical assets but the list of measures has expanded as performance-based decision making has become more important in other agency processes. Transportation agencies' planning objectives tend to relate to outcomes, or impacts on the transportation system. Therefore, a fully integrated performance management system at a transportation agency will use a wide range of performance measures that correspond to strategic objectives and account for outcomes of transportation investments and not only outputs of transportation improvements. These measures will be evaluated in together for a comprehensive understanding of outcomes (Manaugh et al. 2015). In the case that agency goals include sustainability, more specifically equity, measures are less readily available to capture these outcomes. As the industry continues in the direction of data supported decision making with a focus on performance management, it is important to assess progress towards objectives that are more qualitative in nature, such as equity. (Hendren & Meyer 2006, Amekudzi, Fischer, et al. 2012)

In performance-based decision making, outcomes or projected outcomes of transportation improvements are compared based on their ability to support long-range goals. Outcomes related to environmental sustainability can be quantitatively analyzed, as can outcomes related to economic sustainability. However, as discussed in the section on sustainability, components of social sustainability such as equity are hard to quantify. Hendren and Meyer (2006) identify "non-traditional" performance measures. These are measures that are not commonly used in transportation planning and may be external to the transportation system. Measures relating to quality of life, sustainability and economic development fall into this category. Although many agencies espouse these impacts as goals, there are complications that may arise with measuring them. Data availability, causal linkage, subjective valuation, and defining the measures present concerns in using non-traditional measures. One of the performance categories Hendren and Meyer (2006) include is environmental justice as shown in Table 3 below. Furthermore, federal guidance on environmental justice highlights the importance of performance management in nondiscrimination to help develop metric and systematic reporting to meet federal requirements (FHWA 2015b).

Table 3: Example of Performance Measures for Environmental Justice Assessments (Hendren and Meyer 2006)

Environmental Justice	• Comparison of carbon monoxide exposure by race and income (Atlanta Regional Commission) • Comparison of financial investment in transportation by location to race or income level of community being served (Atlanta Regional Commission) • Job accessible within 30 minutes by road by race (North Central Texas Council of Governments) • Job accessible within 60 minutes by transit by race (North Central Texas Council of Governments)

Further performance-based planning guidance is found in two guidebook for performance-based planning and programming published by FHWA in 2013 and 2014. These books adopt central concepts of performance management. The second guidebook

focuses on long-range plans and explains that performance-based plans should be based on baseline information about the system that provides an understanding of the current state, goals and measurable objectives, performance measures, targets, a reporting process, forecasting of future conditions and needs, strategies and a financial plan (FHWA 2014).

2.7 Equitable Transportation Planning

Given the themes of equity theory, sustainability, environmental justice and performance management, one can begin to appreciate that planning for equitable transportation outcomes is a process that incorporates equity considerations throughout the planning process to influence the equitable distribution of outcomes. To do this, equity must first be established as a planning goal and considered among multiple existing and emerging planning priorities. Planning for equitable transportation outcomes does not constitute a new process; however, it widens the application of equity past those populations outlined in environmental justice requirements and applies regionally and across full range of populations. This moves closer to the theoretical construction of equity, addressing the needs criterion for those historically disadvantaged and while evaluating impacts for the whole population, and incorporating the equality criterion. Planning for equitable transportation outcomes continues to address environmental justice regulations and concerns and modifies equity evaluation to address limitations of current analysis practices such as the use of target areas based on high concentrations of target populations and comparison of average impacts. Improved methods examine the spatio-temporal distribution of benefits and burdens of transportation investments – and the extent to which it represents or does not represent equality of access to basic needs (and growth opportunities) – as a key indicator of an equitable transportation system. The feedback from the improved environmental justice analysis is then used to inform decisions through a planning framework of performance

management. Using past outcomes and information on forecasted outcomes in decision making will incorporate equity performance (that is improvements and regressions) into the planning process for future investment decision making. In this way, equitable transportation planning can incorporate cumulative impacts and begin to link procedures for addressing equity in planning to the outcomes of the transportation system. Finally, although equity evaluations at the project level are desirable, planning for equitable transportation outcomes must happen at a program level that affects the comprehensive transportation network including all modes. In other words, planning for equitable transportation must include an effort to capture the spatio-temporal impacts of cumulative transportation investments and incorporate them into decision making toward achieving an equitable transportation system. These tenets are values for transportation planning to achieve equitable outcomes based on the limitations and gaps identified in the literature and in practice. Table 4 summarizes the values including the gaps they address and articulates explicit ways in which they move agencies and the communities they serve towards equitable transportation outcomes.

Table 4: Gaps in Analysis Methods and Planning for Equity

Gaps	Background	Values
Methods	**There are limitations in the quantitative and analytic methods used to evaluate equity in the transportation context.**	
Analytical methods for evaluating environmental justice outcomes narrow the scope of equity to specific target populations.	The focus on historically disadvantaged populations accounts for the needs criteria of social justice; however, planning for public goods encourages the application of the equality criteria as well.	• Expands the evaluation of equity to apply regionally across various populations. • Continues to address environmental justice regulations and concerns.
Target areas do not provide a complete picture of target populations.	Target areas favor high concentrations of target populations and will therefore miss a portion of the target population. They are also sensitive to the threshold used to delineate them. Furthermore, creating geographic representations of populations are subject to the Modifiable Areal Unit Problem and the ecological fallacy of inferring group performance from the performance of a spatial unit. Limitations for using target areas are further complicated when they are developed with aggregated demographic attributes, assuming all target populations are impacted similarly.	• Expands the evaluation of equity to apply regionally across various populations.
Standard equity evaluation practices neglect the pluralistic nature of equity and determine if there is or is not equity by comparing the average impact for target populations to the average impact for a reference population.	The answer to whether an impact is distributed equitably depends on the construction of equity used. Furthermore, using average impacts masks the distribution of impacts on the entire population and by comparing the impacts to a reference population, the results are sensitive to how the reference population is defined.	• Expands the evaluation of equity to apply regionally across various populations. • Identifies gaps in equity outcomes and minimum level of performance.
Analyses of equity outcomes do not account for or include cumulative impacts and lack continuity over planning cycles.	Transportation impacts are distributed temporally; however, data on historic impacts are not used and any temporal consideration is given based on travel demand forecasts. Additionally, improvements to the transportation network over time accumulate to influence outcomes of the system, but these cumulative impacts are not accounted for in equity evaluations, in part because of limitations for temporal analysis.	• Incorporates performance in equity over time into future planning. • Works at the program-level to plan for the comprehensive transportation network.

Gaps	Background	Values
Planning	**There are gaps in incorporating equity into transportation planning.**	
Results of environmental justice analysis are used as a final check of compliance and are not incorporated into decision making.	Environmental justice is the primary vehicle for addressing equity in transportation. Environmental justice analysis is often conducted for compliance with regulations or as a part of NEPA requirements, but federal guidance has begun to assert that environmental justice should have a place in the planning process.	• Incorporates performance in equity over time into future planning. • Considers equity as one of multiple planning priorities. • Continues to address environmental justice regulations and concerns.
Equity is not often established as planning goal.	Only some agencies incorporate equity within their vision or as a policy objective and establish a formal commitment to use equity in planning and decision making. Often equity is not considered at discrete stages in the planning process and is evaluated outside the context of other planning criteria as a check for compliance with environmental justice requirements.	• Considers equity as one of multiple planning priorities.
Performance measures for equity are difficult to define.	Measuring outcomes like equity present issues including data availability, causal linkage, and subjective valuation. In part due to measurement difficulties, equity and other social measures are lacking in sustainability rating systems. Even environmental justice evaluations have limitations in analyzing equity.	• Continues to address environmental justice regulations and concerns. • Incorporates performance in equity over time into future planning. • Identifies gaps in equity outcomes and minimum level of performance.
Procedures to promote equity in transportation planning do not connect to equity outcomes.	At a minimum, all transportation agencies consider equity in planning through public outreach practices. Procedural efforts such as this support equality of opportunity but do not necessarily result in equity of outcomes. Performance-based planning strives to tie outcomes more directly to the planning process, explicitly exploring improvements in procedures to affect improvements in outcomes where necessary.	• Incorporates performance in equity over time into future planning.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter gives an overview of the research methodology. It then explains the analytical comparison of methods that was conducted to compare a comprehensive set of equity evaluation processes. The analytical comparison of methods was achieved by examining three parts of typical equity evaluations: demographic analyses, impact assessments and equity evaluations. The results of the analytical comparison of methods outlined in this chapter support the development of formal procedures for implementing Equitable Transportation Planning. Finally, the chapter explains the process for incorporating these procedures in practice.

3.2 Research Methodology Overview

This research began with an extensive literature review of environmental justice and evaluation methods. This was conducted as part of a larger research project "Impact of Environmental Justice Analysis on Transportation Planning" funded by the Georgia Department of Transportation (GDOT) in 2011 (Amekudzi et al. 2011). Gaps in the technical processes used for environmental justice assessments in transportation were identified and pointed to additional areas of the literature to review: equity theory and social sustainability, especially in relation to equity. As a part of the project "Transportation Asset Management: Organizational Performance and Risk Review," also funded by GDOT (Amekudzi, Fischer, et al. 2012), the performance management literature was researched and has been used to support fundamental knowledge of transportation planning for this research. The literature review and synthesis (Chapter 2) applied the knowledge base in the areas of environmental justice, equity theory, sustainability, and performance management to develop the concept of Equitable Transportation Planning.

The literature review was supported by a set of case studies on transportation planning in four metropolitan regions. Metropolitan planning organizations (MPOs)

were chosen over departments of transportation (DOTs) because although equity may be of interest to DOTs, MPOs have been applying more innovative and comprehensive approaches to address equity. The MPOs selected for case study were chosen based on their application of a transparent equity process and the incorporation of accessibility into this process. Special consideration was given to MPOs of similar size and populations to the Atlanta metropolitan region because the analytical comparison of methods uses the Atlanta Regional Commission (ARC) as an applied case study. Each case study examined the long-range planning process and the process used to evaluate equity at the MPO. The results highlighted limitations in evaluation processes and provided insight into how and if values of Equitable Transportation Planning are currently applied in MPOs.

Based on the literature review and the case studies, a quantitative analysis process was developed to answer the set of research questions outlined in the introduction. The analytical comparison of methods was developed to compare methods from literature and practice, identify gaps for Equitable Transportation Planning, and identify approaches to evaluate equity in a practical way that is grounded in theory. The process had three components: demographic analysis, impact assessment, and equity evaluation. For each of these components, evaluation methods were tested and applied to the ARC planning region. The components were analyzed in parallel and built upon each other and their findings. This chapter outlines the analysis process for each of these components and how the overall process was applied to the Atlanta metropolitan region. The chapter then comments on how to apply the results of the research to develop equity considerations and procedures to formally incorporate equity considerations in the long-range planning process for metropolitan areas. Figure 8 is a representation of the research framework.

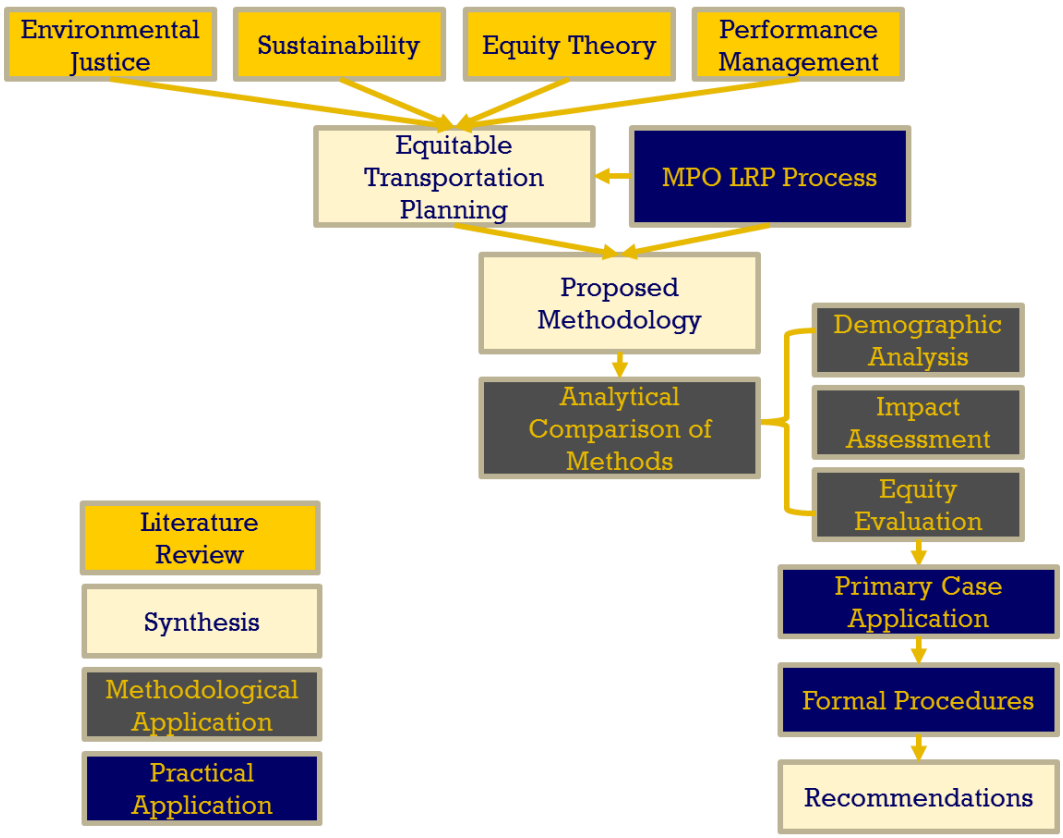


Figure 8 Methodological framework for "Equity Considerations for Long-Range Transportation Planning and Program Development"

3.3 Analytical Comparison of Methods

The application of equity measures must be framed within the current approach to evaluating equity in transportation: quantitative analysis of environmental justice outcomes. Even more innovative methods of equity evaluation model environmental justice analysis and have three components: demographic analysis, impact assessment and equity evaluation. The following three sections of this chapter examine aspects of the current approach, testing and comparing results to answer the following questions:

- How does one develop a demographic profile within a practical spatial unit of analysis to inform program development?
- How can one identify the level of equity of an impact across a region?
- How can evaluation methods inform the long-range planning process to influence equitable outcomes?

3.3.1 Demographic Analysis

The demographics analysis is a necessary component of evaluating equity in transportation planning, especially because of environmental justice requirements. The literature explains that marginalization of certain demographic groups has led to legislation and regulations to address historic disadvantages and improve equity. The Civil Rights Act (Title VI), environmental justice, inclusionary planning and the American with Disabilities Act define the legal context of equity in transportation. These mandates, especially the environmental justice executive order (Executive Order 12898), are also the basis of equity evaluations in transportation. As discussed in the literature review, various socioeconomic characteristics have been defined as significant in equity assessments for different MPOs. Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (1994) characterizes target populations as minority and low-income populations. The Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) further define minority to include: Black, Hispanic, Asian, American Indian and Alaskan Native, and most recently Native Hawaiian or Other Pacific Islander. Low-income is defined as a household at or below the threshold set by the Department of Health and Human Services' poverty guidelines. Transportation agencies therefore include, at a minimum, these groups of people in their analysis. Although the elderly, disabled and child population groups are not explicitly addressed in the environmental justice regulations, these populations are also often considered in practice (FHWA Website, Cambridge 2002). Other groups that have been considered include residents with limited English proficiency, zero-car households, female-head households, adults without high school diplomas, and foreign-born residents. Table 5 shows the criteria the surveyed MPOs use to define target populations.

Table 5: Demographic Segments Identified as Target Populations in Selected MPOs

MPO/DOT	TARGET POPULATIONS											
	Minority	Low-Income	LEP*	Disabled	Elderly	Zero-Car	Single-/Female HOH	Education	Cost Burdened	Foreign-Born	Youth	Housing Values
Atlanta Regional Commission	x	x			x			x				x
Metropolitan Transportation Commission	x	x	x	x	x	x	x		x			
National Capital Regional Transportation Planning Board	x	x	x	x	x							
Puget Sound Regional Council	x	x		x						x		
Boston Region MPO	x	x	x		x						x	
Southern California Association of Governments	x	x		x								
Southeast Michigan COG	x	x			x	x						
Mid-Ohio Regional Planning Commission	x	x		x	x	x						
San Diego Association of Governments	x	x										
Houston-Galveston Area Council	x	x			x	x		x				
Delaware Valley Regional Planning Commission	x	x	x	x	x	x	x					
Maricopa Association of Governments	x	x	x	x								
Central Lane MPO	x	x	x	x	x	x						

*Limited English Proficiency

The current state of practice for equity or environmental justice analysis in MPOs begins with identifying target populations and developing a demographic profile of the metropolitan region. This research applies several approaches for demographic analysis as a sensitivity test of the potential range of results for the applicable processes used to produce demographic profiles of metropolitan regions. Current methods of analysis from literature and practice were tested and compared for several target populations that are frequently evaluated (and required by law): African-American and Hispanic populations and low-income families. The tests were completed for the Atlanta metropolitan region using 2010 US Census and American Community Survey 2013 5-year data. Low-income households are defined in USDOT guidance as populations below the national HHS poverty threshold. MPOs that did use poverty status in practice to define low-income populations used a factor (200% or 150%) above the threshold. Boston Region MPO

defined low-income by the US Department of Housing and Urban Development guideline threshold using 80% of the area average median income (AMI). The draft update for Boston Region MPO imposes a stricter cut-off of 60%. Using AMI provides a geographically sensitive basis for identifying low-income households, especially useful in higher-income and higher-cost-of-living metropolitan areas. In addition to Boston Region MPO, income limits have been set using a percentage of AMI by the Department of Housing and Urban Development and the European Union as well (HUD 2015, European Commission 2013). For this research, family income less than 80% AMI was defined as low-income.

Given the demographic characteristics of target populations, they are considered "any readily identifiable group" of minority or low-income persons either living in geographic proximity or geographically dispersed (USDOT 1997). Defining target populations as such means that impacts can have adverse effects on these persons even when they are not physically concentrated together. Additionally, FHWA elaborates, "[a] very small minority or low-income population in the project, study, or planning area does not eliminate the possibility of a disproportionately high and adverse effect on these populations. Environmental Justice determinations are made based on effects, not population size (CEQ 1997)." Because of this, thresholds to identify areas of target populations, which are often used in practice, do not fully meet this standard since they cannot adequately capture populations that are not concentrated in geographic proximity. This research identified thresholds for demographic analysis that are commonly used in practice and found in literature and applied them in a sensitivity analysis to determine their effectiveness in identifying the intended populations.

As outlined in the literature review, there are several methods that can be used to distinguish a census tract (or other geographic unit) as disproportionately populated by persons of a target population, and therefore classify the tract as a target area. Using the three target populations (African-Americans, Hispanics, and low-income households), target areas were identified in the Atlanta metropolitan area within the 18-county Atlanta

Regional Commission by using four threshold methods: regional average, plus-standard deviation, plus-25 percent and 50 percent. Table 6 provides the definitions of each threshold and Table 7 shows the numerical thresholds for each target population. The regional average for each population was calculated and used to determine the regional average threshold and the plus-25 percent threshold. The 50 percent threshold is a fixed value.

Table 6: Definition of Thresholds

Thresholds	Defines target areas as census tracts with target populations:
Regional Average	greater than the regional average of the target population.
Plus-25%	25% greater than the regional average of the target population.
Plus-Standard Deviation	a standard deviation above the regional average of the target population.
50% of unit	representing 50% or more of the total population of the tract.

Table 7: Thresholds based on Regional Population

	Regional Average	**Plus-25 Percent**	Average Concentration	Standard Deviation	**Plus-Standard Deviation**	**50 Percent**
African-American/Black	**33.38%**	**41.73%**	34.80%	30.76%	**65.56%**	**50%**
Hispanic (non-White)	**10.79%**	**13.49%**	10.71%	12.62%	**23.33%**	**50%**
Low-Income	**44.31%**	**55.39%**	47.15%	22.07%	**69.22%**	**50%**

The plus-standard deviation threshold was determined in both in Excel and ArcGIS. This was done to compare the difference in using the regional average and the average concentration, that is, the average percentage of a target population for the region or the percent of target population for each tract averaged across the region. The regional average was determined in Excel and the average concentration was determined in ArcGIS. The regional average and the average concentration were different, yet, there was only a slight difference in the standard deviation from the regional average between the two (0.1% in the most extreme case studied). Given the functionality of ArcGIS and the negligible difference, the standard deviation for the average concentration was determined in ArcGIS and used as the plus-standard deviation threshold. This threshold therefore represents the average concentration of target population within a census tract plus one standard deviation.

For each threshold in Table 7, a layer was created in ArcGIS to represent the target area and its respective tracts. These target areas were then used to analyze the

population and compare the results for each threshold method using numerical methods. Additionally, maps of the target areas were compared using the spatial analysis techniques, mean centers and standard deviation ellipses. For each threshold layer, a mean center and standard deviation ellipse was calculated in ArcGIS. The mean center represents the spatial center of gravity for tracts in each of the target areas; it explains where the tracts of the target areas are centered. The standard deviation ellipse draws an ellipse that covers 68% of the geographic area of the target area. It provides an understanding of where the tracts within the target area are concentrated and how widely they are distributed spatially.

To further compare the target populations, a target area was delineated to show tracts that surpassed the regional average threshold for either African-American or Hispanic populations. Income was added as a variable and a target area with census tracts where either minority populations OR low-income populations met the regional average threshold were defined. Finally, a target area where both minority populations AND low-income populations were above the regional average was also identified. These combined demographic profiles were compared to the Equitable Target Areas (ETA) developed by ARC. The ETAs were developed using the target populations of racial minorities (African-American, Hispanic, Asian and other non-white populations) and poverty households. The process for delineating ETAs is explained in detail in Chapter 6.

Demographic profiles of the entire target population were also created to address the greater dispersion of target populations outside of the target areas delineated by thresholds. Maps of the distribution of the target population were created. The maps highlight census tracts with high numbers of target population as opposed to high concentrations.

A note must be made on the use of census tracts. Census tracts were used in this research as opposed to block groups. The 2010 traffic analysis zones (TAZs) align with block groups which provide more precision in the demographic analysis and do not require aggregation of travel demand results. This is the preferred scale for analysis. However, due to data limitations, census tracts were used. Auto travel time was

determined using the 2000 TAZs and they do not align with the block groups. The 2000 TAZs do, however, align well with the tracts. If demographic profiles using block groups were compared to the auto accessibility for the 2000 TAZs, useful results are not expected because of the difference in spatial units. It would also make comparison between the transit and auto accessibility less clear. For consistency between modes and accuracy in comparing accessibility results to demographics, census tracts were used and not block groups. This process is further explained in the following section.

3.3.2 Impact Assessment

The second element of the methodology is an impact assessment; this research applied accessibility as the impact of interest (although there is the potential to assess other impacts such as safety or air quality). MPOs are now more frequently including accessibility as a priority and as such have been developing approaches to measure it. These methods range from calculating average commute time to activity-based models of travel times. Accessibility can generally be viewed as a measure of places or a measure of people (Halden 2005). A measure of places takes a spatial approach to accessibility and identifies the characteristics of transportation use in various general areas such as rural areas or mixed-use neighborhoods. A measure of people has a categorical approach and identifies with the travel patterns, preferences and needs of particular social groups such as women or the disabled. Further distinguishing accessibility measures, there are four components of accessibility that are identified in definitions and measures of accessibility: land-use, transportation system, temporal conditions, and individual preferences (Geurs 2004). The land-use component depicts the spatial distribution of opportunities and destinations, the demand for these opportunities and the competition between the destinations. The transportation component reflects the generalized transportation costs experienced between an origin and destination using a specific mode. The temporal component describes the time sensitivity of opportunities and their availability throughout the day. The individual component depicts the needs, abilities and opportunities that influence an individual's travel. Each of these components should ideally be accounted for in accessibility measures; however, application of all would be

very complex and impractical. Accessibility measures in practice generally address one or more of these components based on the perspective that is taken.

Four basic perspectives are identified by Geurs (2004): infrastructure-based, location-based, person-based and utility-based. An infrastructure-based perspective to accessibility focuses on the potential mobility of the system, the level of service of the transportation network. A location-based perspective measures accessibility based on the spatial distribution of opportunities, generally on a macro-level. A person-based perspective accounts for an individual's time budgets and schedule. Lastly, a utility-based perspective approaches accessibility from the benefits that are derived from the opportunities.

Bringing together Halden's (2005) concept of spatial and category accessibility and Geurs' (2004) components and perspectives of accessibility, Figure 9 was distilled to provide a framework for understanding and selecting approaches to measuring accessibility.

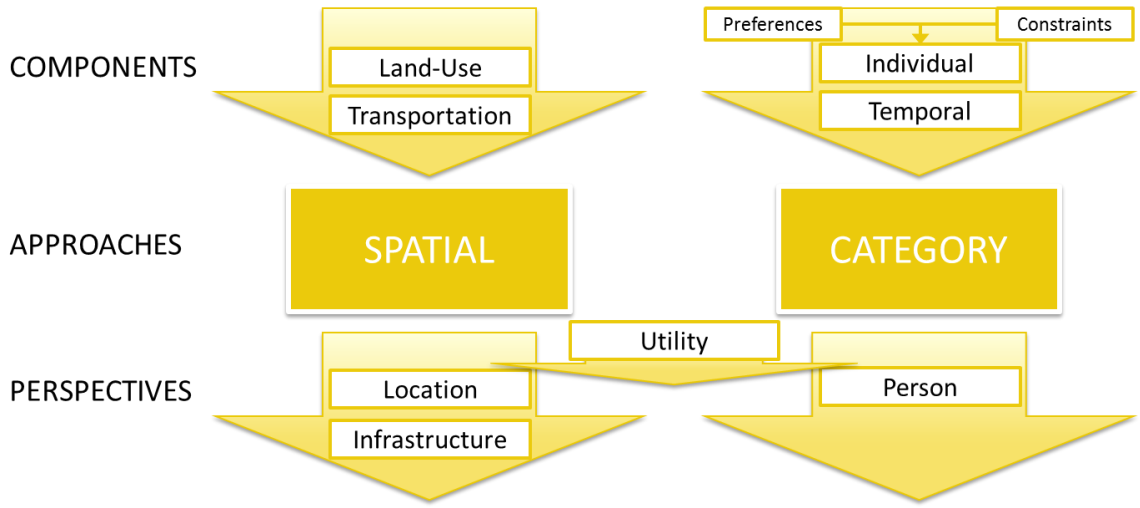


Figure 9 Framework for categorizing and selecting accessibility measures

The arrows at the top of the framework represent the input components and based on the approach, the accessibility measure will have a location or infrastructure perspective (spatial) or a person perspective (category). A utility perspective can result from either approach and a combination of approaches can result in various perspectives.

Land-use and transportation components are used in a spatial approach. This approach results in viewing accessibility as an attribute of places through an

infrastructure- or location-based perspective. This approach can be useful in analyzing travel behavior based on the urban form of an area (Halden 2005). However, activity patterns vary between social groups and even within geographic boundaries. A category approach views accessibility as an attribute of people through a person-based perspective. Individual and temporal components are used in a category approach. Note that preferences and constraints play into the individual and temporal components. This approach helps to analyze select social groups within an area-based framework (Kwan and Weber 2003). However, social groups differ from location to location. Halden (2005) suggests using a combination of the two approaches to assess accessibility. Approaching accessibility both spatially and categorically can address multiple components by measuring accessibility using various perspectives.

3.3.2.1 Conventional Accessibility Measures

Accessibility has conventionally been measured using gravity models. The gravity model is based on the premise that attraction is proportional to the number of destinations in a zone and inversely proportional to the distance between the origin and destination zones. The gravity model results in a summation of destinations weighted based on some form of generalized cost (e.g. travel time). The commonly used form of the gravity model accounts for the generalized costs through a negative exponential function otherwise referred to as the impedance function (see Table 8). The impedance function in the form of the negative exponential addresses issues with very close locations and also associates well with travel behavior (Geurs 2004). The cumulative opportunity model is a simplified form of the gravity model that does not use an impedance factor but instead assumes that all opportunities within the zone have the same attractiveness (see Table 8).

Both the gravity model and cumulative opportunity model follow the conventional mindset based on spatial logic. This mindset views accessibility as an attribute of places rather than of people (Kwan and Weber 2003). The gravity model accounts for the opportunities that are available to the user but neglects factors such as individual preferences or temporal conditions (Dong et al. 2006). It also excludes the effects of competition amongst opportunities. In addition, conventional methods may

also be less accurate if they account for Euclidean distance rather than distance constrained to the existing transportation network.

Another major drawback of conventional methods is the zonal focus. Intrazonal trips are often excluded from conventional methods of measure. This causes walking and cycling trips to be neglected in accessibility measures unless modifications are made to customize impedance functions (Iacono et al. 2010). Even with customizations, gravity models measure accessibility by one specified mode and do not account for the multi-modal nature of actual travel.

3.3.2.2 Advanced Accessibility Measures

Conventional methods for measuring accessibility do not account for individual differences, even when disaggregate level data is used (Kwan and Weber 2003). Measures that account for individual preferences are more sophisticated than the gravity model and are more able to represent complex human spatial behaviors and the actual urban environment. Conventional methods also neglect temporal considerations. They do not account for scheduling of events, traffic congestion, changes in transit schedules, or patterns of business hours (Kwan and Weber 2003). Space-time measures on the other hand, are based on personal and social constraints and take a person-based perspective. These measures account for individual preferences and temporal conditions. Furthermore, the modifiable areal unit problem (MAUP) of aggregated data is not an issue with space-time measures because the measures have little to no relation to distinct geographic scales (Kwan and Weber 2003, Neutens 2010).

Other advanced methods include models based on utility theory. The utility derived from a destination guides this approach; however, it is not possible to know with certainty what this utility will be. Using random utility theory, an accessibility measure can employ multinomial logit models to capture individual preference (Dong et al. 2006). Activity-based accessibility builds upon random utility and incorporates the range of activities pursued throughout the day and the schedule of these activities, and accounts for trip-chaining by using a day activity schedule to model the all trips that an individual takes in a day (Dong et al. 2006). This incorporates individual components and moves

away from trip based measures. Measures with a utility perspective have the opportunity to incorporate both approaches and a variety of the components of accessibility measures.

There is an increasing number of measures that provide a more comprehensive understanding of accessibility, accounting for mode, activities schedule and individual choices. As distance becomes less of an indicator for accessibility (Kwan and Weber 2003), more advanced methods are necessary to measure it and more methods are being developed. Table 8 summarizes existing accessibility measures and categorizes them according to their corresponding theoretical bases. The conventional cumulative opportunity and gravity methods take a location-based approach and incorporate land-use and transportation components. Individual measures like space-time have a person-based perspective and account for both temporal and individual components of accessibility. Random utility theory models obviously have a utility-based perspective and account for transportation, land use and individual components (Figure 9). Activity-based models using random utility also account for the temporal component. Advanced methods are continually being developed and modified that view accessibility through different lenses and account for temporal conditions and individual preferences.

Table 8: Summary of Accessibility Measures

Method	Perspective	Description	Advantages	Disadvantages
Cumulative Opportunity	Infrastructure-Based Location-Based	$A_i = \sum_j W_j a_j$ where: A_i = Accessibility of zone i W_j = weighting factor a_j = attractions in zone j	- Meets transportation system criteria - Easily computed and interpreted	- Does not account for land use patterns, temporal constrains or individual needs - Neglects costs and power of attraction - Highly susceptible to the weighting factor chosen
Gravity Model	Infrastructure-Based Location-Based	$A_i = \sum_j a_j f(c_{ij})$ where: A_i = Accessibility of zone i a_j = attractions in zone j c_{ij} = generalized cost between i and j	- Meets both transportation and land use criteria - Useful for area-based, aggregate analysis of social groups	- Does not account for temporal constraints or individual needs - Excludes competition effects - Analysis at different scales (i.e. local, regional) cannot be combined

Method	Perspective	Description	Advantages	Disadvantages
Space-Time	Person-Based		- Generally meets all criteria - Frameless (MAUP not applicable)	- Data intensive - Require complex algorithms and GIS expertise - Difficult to aggregate for evaluation of groups
Random Utility	Utility-Based	$A_i = \frac{1}{\lambda} \ln(\Sigma e^V)$ where: A_i = Accessibility of zone i λ = scale parameter V = systematic portion of utility for a person in zone i	- Meets both transportation and land use criteria and also individual needs - Can capture all modes	- Does not account for temporal constraints - Complex math required
Activity-Based	Utility-Based		- Meets temporal constraints - Takes trip chaining into account	- Complex math required

3.3.2.3 Measuring Accessibility in Practice

A suite of performance measures commonly collected may be used as a proxy for accessibility. Metrics such as distance from transit stops and average travel time to work have all been collected by agencies to measure accessibility. These metrics, however, do not fully capture accessibility. Some agencies have used conventional methods, such as the gravity model, to evaluate accessibility but advanced methods are less common.

The Atlanta Regional Commission uses two methods to measure accessibility in their Transportation Assessment for the 2016 long-range plan update. Both focus on transit accessibility because although the level of auto accessibility is deemed accessible throughout the region (Hall 2014), the ARC identified a need to increase transit accessibility.

One measure of accessibility focused on areas where target populations of minority and low-income households were concentrated (Equitable Target Areas, or ETAs). ARC identified transit travel sheds to major hospitals, libraries, K-12 schools, higher educational institutions, and grocery stores by determining the area around each destination within a certain transit travel time (30 minutes for grocery stores and 60

minutes for the other destinations) using OpenTripPlanner. ARC produced a set of maps that show the travel sheds for each type of destination within ETAs and provide a type of destination-based accessibility measure. Accessibility to low-wage jobs is also estimated by calculating how many jobs earning less than $1,200 per month are in each census tract. This information was compared to the area within a half-mile from a transit stop and the ETAs. Finally, the half-mile buffer area around all public parks was compared to the ETAs to determine accessibility to park space. The mapping exercise attempts to understand what opportunities are actually available via transit and the location of those that have access to these destinations. The focus in these maps is on individual opportunities and a population subset, however, because of the narrowed scope, a better understanding of what opportunities are actually accessible can be obtained.

The second approach to measuring accessibility in ARC reflected that regional centers that are well connected via transit are able to reach a larger pool of potential employees. The ARC identified 14 areas of concentrated jobs and activity from the Unified Growth Policy Map (UGPM) and the Regional Development Guide. Figure 10 shows the Regional Centers that have 10,000 or more jobs within four square miles. ARC examined transit access (rail, local bus and commuter bus) to the Regional Centers using data from OpenTripPlanner to determine average travel times during AM peak. The Transportation Assessment provides two examples of the results. Figure 11 shows the transit accessibility for the Midtown and Cumberland Regional Centers. While there is an assumption that the Regional Centers represent the vital destinations for the region, this method of measuring accessibility can be used to produce a regional understanding of accessibility. For this research, the method for measuring accessibility was modeled in this way.

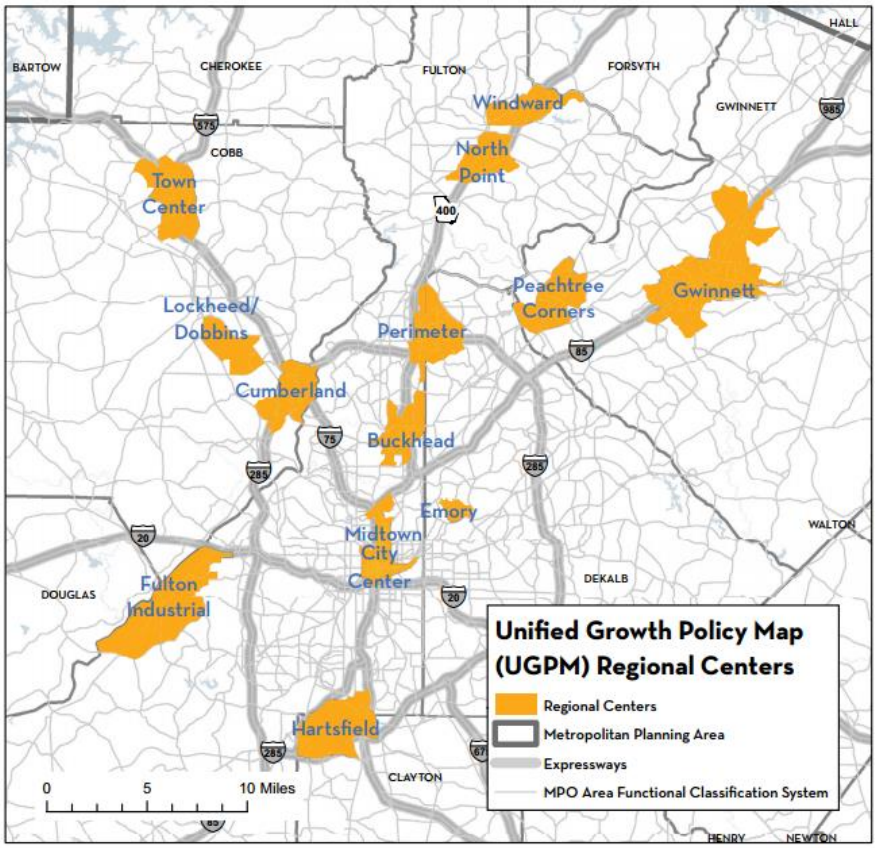
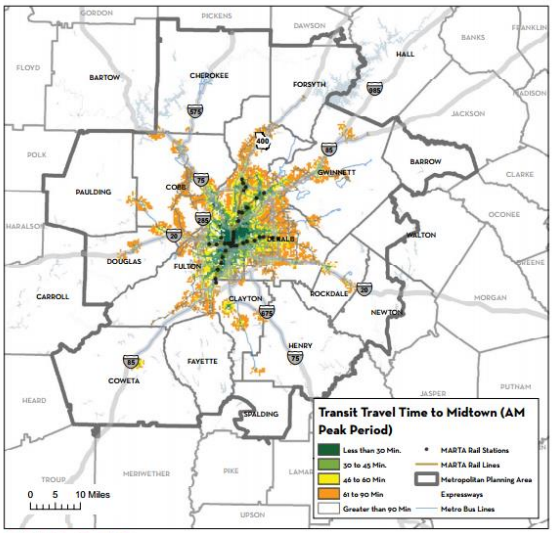
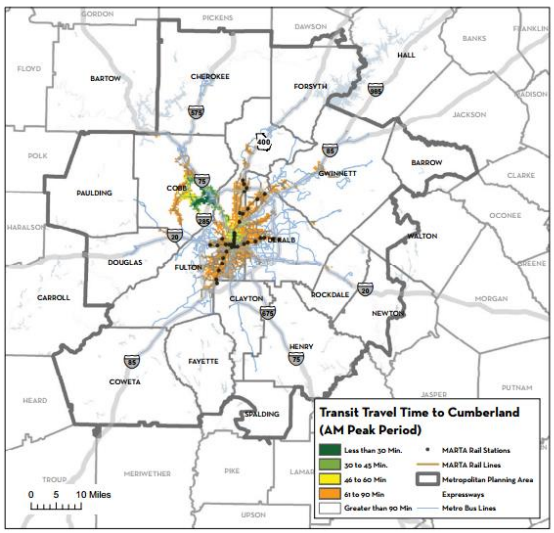


Figure 10 Regional Centers from the Unified Growth Policy Map (ARC 2015a)



MAP 3.10 *Transit Travel Time to Midtown During AM Peak Period*



MAP 3.11 *Transit Travel Time to Cumberland During AM Peak Period*

Figure 11 Transit travel times to Midtown and Cumberland Regional Centers during AM peak (ARC 2015a)

The average transit travel times to Regional Centers was obtained from ARC. The data for the analysis was obtained well in advance of the publication of the Technical Assessment and has a slightly different set of Regional Centers. Windward and Lockheed/Dobbins were not included and Southlake was included because the major employment centers were located in the north of the region although it was unlikely that all residents in the south of the region traveled to these northern work centers. This created a total of 13 Regional Centers that were used for this research. Using the shapefile available through ARC, the 13 regional centers were selected and associated with census tracts using ArcGIS.

The data provided an average travel time from each TAZ to the 13 regional centers as well as the calculated mean travel times across all the 13 regional centers from each TAZ. Those with no access to the regional center (0 or 128 minutes) were excluded from the analysis. The resulting measure attempts to account for both the land use and transportation components, assuming the attraction of the regional centers by the availability of jobs. One thing to note is that there is no weighting based on the number of jobs. All regional centers are assigned the same level of attraction but locations that are not regional centers are neglected (assuming 0 attraction). This process could be likened to a gravity model assuming a_j, the attraction, is 1 for regional centers and 0 otherwise and using the travel time as the friction cost factor. Therefore, the accessibility of each TAZ is additive and can be taken as the summation of accessibility to all regional centers. With this understanding, a mean travel time, such as the one calculated in the technical assessment, does not represent accessibility. For this research, each TAZ was given a score based on the level of accessibility to each regional center and the totals were added to produce a total accessibility score. This score allows for a relative comparison of accessibility across TAZs and is discussed later.

For consistency of results, the same 13 regional centers were used in evaluating the auto accessibility. The travel time data for auto trips was acquired from ARC based on the travel demand model. It is the output for automobile travel based on the modeled congested highway network for the base year 2015. The base year results used the 2015 highway network and the 2000 TAZs. The results of the model produced a 2118 by 2118 matrix of all 2000 TAZS (internal and external) but it was important to understand which

TAZs represented travel time FROM and travel time TO to select the correct travel times to analyze. Once this was determined, the travel time to each regional center from each TAZ was extracted from the matrix. This process required determining the linkage between the 2000 TAZs and the 13 regional centers. This was done by associating each regional center from the ARC shapefile to census tracts by selecting all census tracts with centroids within the polygons of the 13 regional centers. The regional center shapefile contains all of the regional centers from the 2011 UGPM and other smaller areas of regional significance but only the tracts that related to the 13 regional centers of concern for this research were included. The TAZs also had to be associated with census tracts. This was done in a similar manner, by joining all TAZ that had a centroid within a tract to that tract. Both operations were done using spatial joins in ArcGIS.

The result of the spatial joins was a set of tables containing census tract identification numbers, TAZ numbers and the identification numbers for tracts and TAZs within the 13 regional centers. The tables were joined with travel time data in MS Access to cope with the large amount of data and a consolidated table was exported into excel for calculations. Unlike the transit travel times, there were multiple auto travel times to each regional center (because the matrix had travel time to TAZ and there were multiple TAZs in each regional center). The average travel time to each regional center from each TAZ was calculated in excel.

With a travel time table for both transit and auto travel to the regional centers associated with TAZs and tracts, accessibility scores for each TAZ could be calculated. The accessibility measure used in this research is a score ranging from 0 to 2, 0 reflecting low accessibility, 1 medium accessibility and 2 high accessibility. The scores are based on the travel time to the 13 regional centers and the mode. The distinction between high, medium and low accessibility is based on the delineation used in PLAN2040. For transit, low accessibility is an average travel time greater than 45 minutes, medium access is an average travel time between 25 and 45 minutes and high accessibility is an average travel time less than 25 minutes. Auto accessibility is deemed high if it is less than 10 minutes, medium if it is between 10 and 30 minutes and low if it is greater than 30 minutes. The travel times and corresponding scores can be found in Table 9. Scores for each TAZ were calculated based on this scale in Excel. In addition, a composite score (summing

the scores for each regional center) was calculated as well as the total number of regional centers with high, medium, low or no access to each tract was calculated.

Table 9: Accessibility Scores and Corresponding Travel Times

	Level of Accessibility		
	High	Medium	Low
Mode			
Transit	<25	25-45	>45
Car	<10	10-30	>30
Score	2	1	0

Before importing the accessibility scores into ArcGIS for comparison with the demographic profiles, it was necessary to aggregate the scores to the tract level (because there are multiple TAZ in most tracts). The 2000 TAZs are different from the TAZs used in the transit accessibility analysis (the current model TAZs); however, both sets coincide with census tracts. To standardize the comparison as well as make it useful for demographic analysis, which is based at the census tract level, accessibility scores were calculated for census tracts. This was done by determining the average accessibility score for the tract. In other words, the average accessibility of the TAZs in the tract was the estimated accessibility of the tract. This was done to estimate the access across several TAZs. It was not added because each tract represented one origin, unlike each Regional Center which represents one destination for many origins. An aggregated table of the accessibility scores for each tract was created for both auto and transit accessibility and imported into ArcGIS. The accessibility for the region could then be analyzed in light of the demographic profiles to evaluate equity. This evaluation is explained in the next section.

3.3.2.4 Limitations of Impact Analysis

There are some limitations to the accessibility measure used for this analysis. Scales of analysis differed for the auto accessibility and the transit accessibility; transit data had a substantial amount of extreme values that were not included in the analysis, and there was no weighting for attraction of regional centers.

One limitation occurs because the auto and transit accessibility were determined using two different sets of TAZs. Both sets of TAZs, however, aligned with census tract data; therefore, accessibility results were aggregated to the tract level for tracts with multiple TAZs. A spatial join (center within) was used to estimate with which tract each TAZ should be associated. For each tract, the accessibility scores for TAZs within it were averaged and the final result was an average accessibility for each tract to all of the regional centers. There was some additional difficulty aligning the 2000 TAZs and the estimation led to some tracts not having centroids of TAZs contained within them. As a result, there were some (42) tracts without auto accessibility scores.

The aggregation did however address an additional limitation for comparing the impact result and the demographic profiles. TAZs align with census blocks for the 2015 plan update and will provide more precise results for both impacts and demographics. Given the data limitation in this research (one set of TAZs did not align with blockgroups), tracts were used as a least common denominator in order to compare the results across a consistent set of demographic data. The limitations resulting from different scales of analysis highlight concerns for MPOs that do not use TAZs that coincide with tracts.

There are also limitations based on the data itself. The transit travel times had a lot of missing values (0s and 128s) and was only primarily MARTA service areas (Fulton and DeKalb) although there was some service in Gwinnett. Additionally, despite being adjacent to regional centers, some TAZs were not considered accessible because data was missing. The process used to determine transit travel times is also new and has limitations, yet it does provide ground truth information on transit travel times.

The 13 regional centers were dictated by the transit assessment that was conducted in advance of the final Transportation Assessment. Although they are not arbitrary, they do not align with the 14 Regional Centers that ARC has defined in their UGPM. There is also no weighting for the level of attraction for the regional centers and there is no factor to evaluate what types of jobs and services are provided at each regional center and if these are desirable to those that have access.

Auto travel times are estimated based on the travel demand model. This is a conventional practice but the general limitations of using travel demand modeling (4-

step) are therefore assumed. Also, unlike the transit data, the auto travel times are modeled and not collect directly from the system.

The TAZs are different between the two mode analyses but because the results are aggregated to the tract level, they are comparable. Travel time data was not aggregated at this level to preserve some accuracy, but the resulting scores were averaged. The scores were devised to have built in weighting (high accessibility score two times medium accessibility score). Still the tract scores do not easily reflect the difference between having high and medium access (a score of 6 can mean either 3 tracts with a high score or 6 tracts with a medium score). Along the same grain, high accessibility was not given additional weighting because it is not clear that having very high accessibility to one regional center is more beneficial than having medium accessibility to multiple. This supports the need for a more precise analysis of impacts with the aim of reaching a balance of precision and pragmatism.

Regardless of the quantitative limitations of the accessibility measures, they can be used to develop a standard impact profile for the region that can be used to evaluate regional equity.

3.3.3 Equity Evaluation

The final component of the analytical comparison of methods is the equity evaluation. This process seeks to identify if there are areas of improvement for equitable outcomes. Given the pluralistic nature of equity, it is not possible to determine if an impact is unequivocally equitable; however, it is well within the realm of possibility to identify when it is not equitable. Equity evaluations, therefore should strive not to prove equity, instead they should aim to identify if or how a set of conditions is inequitable. They should then explore ways to address inequities and approach equitable outcomes. The literature review and case studies show that "equity" has been determined in several ways. The first is most common to environmental justice analysis. An impact, in this case accessibility, is compared between target areas and non-target areas and the difference in the average accessibility between the two areas is compared to check for substantial disparate impacts. The fundamental desire in this process is to prove equity, as showing inequity can lead to unfavorable reactions from the public, federal and state

entities, and others. If equity evaluations are approached more as an element of a long-range planning process, as opposed to an assessment for compliance, the incentives to honestly examine the equity of impacts are increased.

In practice, accessibility for target populations is determined to be either on par with a reference population or not. If it is not, then it is determined if the difference is significant. The process generally defines accessibility as the average travel times to opportunities or the average number of opportunities within a travel time. Accessibility is compared between target and non-target populations or between base year scenarios and forecasted scenarios for target populations. Statistical methods are not necessarily used to compare impacts and small differences may be taken as insignificant. The comparison of average impacts is often based on the location of target areas identified by thresholds as discussed in Chapter 2.

For this research, the data for transit and auto accessibility was joined with the thresholds identified in the demographic analysis in ArcGIS to evaluate the level of access available to the target populations based on threshold analysis. For each threshold, the tracts with scores above 1 (i.e. tracts with medium or high access) were considered accessible and information such as the number of tracts, target population and total population with access were collected to compare the sensitivity of thresholds on impacts. This is similar in process to the standard process of delineating a target area based on thresholds and assessing the impact on the target population.

Another method used for equity evaluations are rational methods. Rational methods were discussed in the literature but are not often found in practice. The three rational methods discussed in the literature review – Buffer Comparison Index, Area Comparison Index, and Population Comparison Index – were compared in a sensitivity analysis similar to threshold methods to explore the effects of using different indices. For the comparison, African-American, Hispanic and low-income populations were compared separately as well as in the combined target areas.

In both the threshold and rational methods, the equity evaluation is based on a reference population. In the threshold method, the average impact on target populations is evaluated for similarity with either non-target groups or the general population. In the rational methods, a set of ratios is used to determine how similar the impact is for the

target and reference populations. Both cases concern themselves with a singular point of information, either an average or ratio. This focus neglects the bigger importance of distribution of impacts.

This research develops an approach to evaluate distributions. It provides the opportunity to compare distributions against a reference population, but it also creates an opportunity to understand the distribution of benefit across populations with various demographic characteristics. The process outlined in Figure 12 modifies the quantitative analysis for environmental justice to support a quantitative equity analysis for cumulative impacts based on evaluating the distribution of an impact across the population. It is proposed to address the limitations of the current methods used to evaluate equity.

Figure 12 Proposed process for equity analysis of cumulative impacts.

The process starts with a focus on the impact and uses the demographic profile to evaluate the distribution of the impact across the regional population and segments of the population. Finally, this information is used within the regional context to inform decision for programming the long-range plan.

First the process determines how impacts are distributed across a regional space by identifying distributive effects (independent of demographic profiles). Given the distribution of the impact, areas of "disadvantage," i.e. areas with low accessibility, are identified. Several approaches to evaluate equity based on this information can follow. The first identifies the distribution of accessibility for all target populations. It determines what percentage of each target population experiences high, medium and low accessibility. These distributions can be compared against each other and to the regional distribution. This method does not address the limitation of a reference population but it

presents a description of how population segments across the region may be affected differently.

Another approach that builds on the distribution of impacts across a population looks at each target population independently and analyzes the gap between those that have low accessibility and those that have high and medium accessibility. For any target population, differences between the portion of the population with low accessibility and those with medium and high accessibility can be highlighted to identify gaps in benefits.

The next method compares the population with low accessibility to the areas of high and medium accessibility. The composition of the population in the composite low areas of accessibility for the region and those in the medium and high areas are compared for dissimilarity, similar to rational methods and comparison of target and non-target areas used in the literature. This moves past focusing on target populations and any one population can be compared independent of a reference population. The area of low accessibility can also be explored independently. The demographic breakdown of the area of low accessibility can provide important information on who is disadvantaged by the transportation network. Collecting this information over time and comparing it across planning cycles can begin to identify patterns that can be addressed to reduce forming inequitable outcomes.

Each method provides the opportunity to focus on any population, those mentioned in the research or other, and analyze effects on that population. They also do not focus solely on target populations but do provide opportunities to specifically measure target populations. This allows an analysis of any and all populations of the region to assess the equity of outcomes in a comprehensive manner. The proposed methods are independent of thresholds, do not create target areas based on concentrations of population and in some cases do not require comparison with a reference population, addressing some of the limitations of current practice. The proposed approach also evaluates the distribution of the impact across a population and does not compare a single point of central tendency.

Finally, the methods can all also be conducted continually and the results can be evaluated over time. Repeating this analysis process incorporates the temporal component for cumulative impacts: an important factor of equity. Once a baseline has

been measured, the analysis can continually be conducted during long-range planning update cycles and compared over time. They are all derived from a spatial context and the geographical component can be used to provide additional information in the analysis. A significant point is that comparisons are typically based on travel demand models. These forecasts provide important information for planning but the populations are synthetic and land use patterns are forecasted introducing a fair amount of uncertainty into the evaluation. The use of historical data or a benchmarking process is not commonplace currently.

All of these analysis methods produce information that can tell a story about equity within the context of the region. The final step in the proposed process is a contextual analysis. This step helps to move the focus of an equity analysis from identifying if the results are equitable to asking what the results say about gaps in performance and highlights the qualitative component of the analysis. To support the quantitative analytical comparison of methods, qualitative research, as discussed in the next section, was conducted.

3.4 Formal Procedures for Equity Considerations of Cumulative Impacts

The goal of this dissertation research is not to answer the question "is it equitable?" It is to provide useful information to incorporate equity into the planning process in an effort to move towards equitable outcomes. For this reason, it is important to identify paths of influence for equity considerations. The literature review led to an understanding that equity considerations would be most effectively applied during the performance management cycle. To understand how this can be done in practice, four case studies were reviewed. The cases were selected based on population size, incorporation of equity in planning objectives, use of performance management practices, and evaluation of equity using accessibility. The case studies not only served to provide background information, but provided insight into the needs for and limitations of integrating equity considerations into decision making. Further explanation of the methods used and the results of the case studies can be found in Chapter 4.

The case study results, literature review findings, and the results of the analytical comparison of methods were used to develop recommendations for long-range planning

of transportation systems to achieve equitable outcomes. Borrowing from policy analysis to compare the implementation of practices across the case studies, the values of Equitable Transportation Planning distilled from the literature review were compared with the cases in practice. The results of this analysis along with the quantitative results of the analytical comparison of methods further highlighted gaps, which were then used to develop of a set of recommendations for methodological procedures and planning processes.

CHAPTER 4

CASE STUDY REVIEW: PLANNING FOR EQUITABLE TRANSPORTATION OUTCOMES IN MPOS

4.1 Introduction

This chapter presents the findings of four case studies of metropolitan planning organizations (MPO) that were identified for comparison to the Atlanta regional planning agency, the Atlanta Regional Commission (ARC). The cases were selected based on the MPO's performance-based planning approach, equity evaluation procedures, accessibility measures or some combination of these practices and were studied in light of the concept of Equitable Transportation Planning. The case studies were examined for their incorporation of equity into project programming processes and the focus on equitable outcomes in the planning process. This forced a focus on performance-based planning. The methods used to evaluate equity were of particular concern for their ability to align the analysis with a better understanding of the theories of equity and to expand the process by examining a wider range of concerns (i.e. additional populations and geographies). Additionally, the importance of cumulative impacts for Equitable Transportation Planning encouraged the exploration of any methods for understanding the effects of investments on a network level and over time. For each MPO, comprehensive and transportation planning, equity procedures and measurement of accessibility are detailed, highlighting innovative procedures as well as limitations based on the findings of the literature review and the concept of Equitable Transportation Planning. Each case study and the introduction highlight the planning process and the methodology for evaluating equity in separate sections with some concluding remarks.

4.1.1 Long-Range Planning in Metropolitan Planning Organizations

Metropolitan planning organizations manage the metropolitan transportation planning process shown in Figure 13. In particular, they are responsible for developing long-range transportation plans and approving the program of projects that will receive

federal funding. These steps in the planning process are requirements for federal transportation funding and although MPOs across the country have different levels and ranges of power, these planning steps have significant influence over the development of the transportation system. The long-range transportation plan sets the direction for decision making in the region and through the development of the Transportation Improvement Program (TIP), MPOs approve the major transportation improvements for urbanized areas. Through the development of case studies, this chapter reviews how four agencies translate visions and goals through strategic planning to the development of the TIP (Figure 14). Figure 14 is a variation of Figure 13, providing details to highlight performance management within the regional planning process. In these cases, special attention was paid to the incorporation of equity into the vision and goals and how they were then propagated through the process.

Figure 13 Metropolitan Transportation Planning Process (FHWA 2007). Note the development of the long-range plan and the TIP within the process.

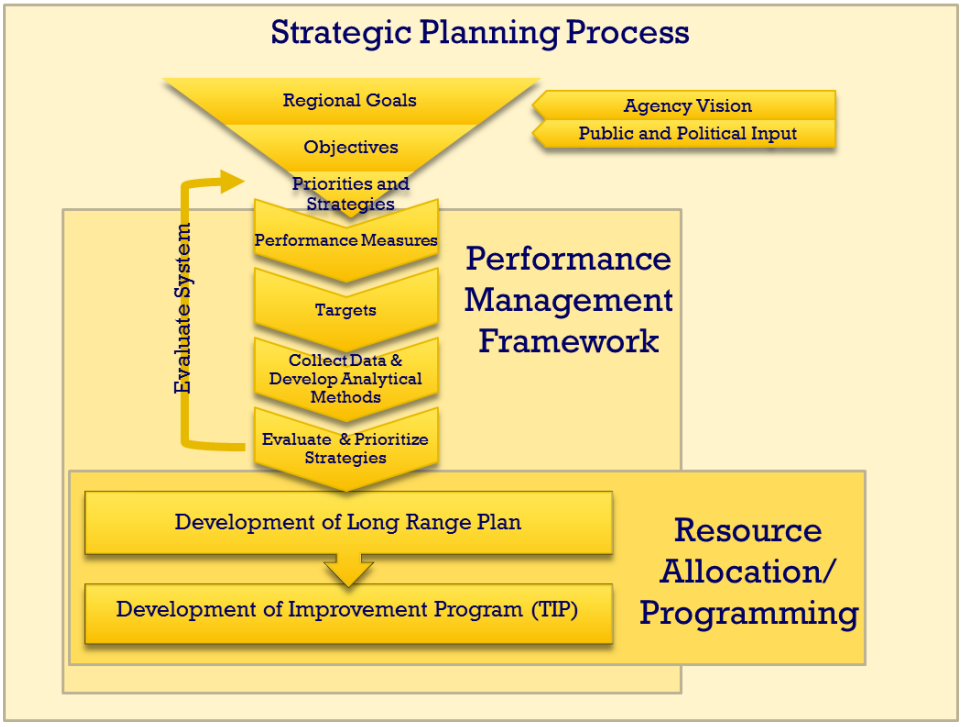


Figure 14 Performance management framework within strategic planning for the Metropolitan Transportation Planning Process.

4.1.2 Equity Evaluations using Quantitative Analysis of Environmental Justice Outcomes

Considerations for equity in the case studies were typically addressed through the lens of the appropriate federal requirements, in particular, environmental justice. Environmental justice can be defined as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income" in relation to the development, implementation, and enforcement of regulations and policies (EPA n.d). Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, with the legal backing of Title VI of the 1964 Civil Rights Act, requires all federal agencies, including the Department of Transportation (USDOT), to develop environmental justice regulations. The USDOT outlined specific goals and regulations for environmental justice based on three fundamental guiding principles (USDOT 2012):

1) To avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations.

2) To ensure the full and fair participation by all potentially affected communities in the transportation decision-making process.

3) To prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority and low-income populations.

These three principles account for disproportionate burdens, inclusive participation, and equitable receipt of benefits, reflecting both procedural and outcome equity. Full and fair participation in the decision-making process relates to procedural equity. Outcome equity relates to the distribution of burdens and benefits. This research concentrates on outcome equity.

Common practice focuses on the distribution of burdens, but trends in practice show that benefits of transportation improvements, especially accessibility, are being considered more often. Quantitative analysis of environmental justice outcomes is most often used by transportation agencies to assess the distribution of burdens, and to a lesser degree, benefits (Amekudzi, Smith, et al. 2012). It estimates the distribution of impacts across the population, especially across target populations, and attempts to measure distributive effects. The desirable result for outcome equity is distributive effects that are equitable (not necessarily equal) across various segments of the population, where the impacts of transportation improvements are deemed equitable (i.e., fair, reasonable) by various stakeholders.

Quantitative analysis of environmental justice outcomes can be organized into three steps: identification of the population and study area that will be impacted, determination of the impacts resulting from the transportation improvement, and an analysis of the distributive effects for disproportionality (Figure 15). A detailed explanation of the process can be found in the Literature Review chapter.

Figure 15 Existing framework for quantitative analysis of environmental justice outcomes.

The three-step procedure for quantitative analysis of environmental justice outcomes is most applicable for project-level evaluations; however, MPOs generally evaluate the total program of projects and assess regional impacts with limited emphasis on evaluating individual projects. Additionally, regional evaluations often focus on regional cumulative impacts, such as accessibility, that require a macro- and regional-level analysis. Additional limitations of the quantitative analysis framework are discussed in the literature review. The following section provides an overview of the process and how it is applied at the regional level.

The first step outlined in the quantitative analysis of environmental justice outcomes is defining the population and study area. For regional impacts and network-based outcomes, the entire region becomes the study area. The target population, however, can be defined in several ways accounting for minority and low-income populations at the minimum. The quantitative analysis procedure also requires that a reference population is defined to which the outcomes for the target populations are compared. In the case studies, the reference population is either taken as the aggregate of residents in the regional area, the residents that are not considered within target populations, or the residents that lived outside of target areas. The target areas are commonly delineated in regional analyses. To do this, a demographic analysis is conducted to locate areas in the region with high concentrations of target populations and the target populations are then represented spatially by census tracts or TAZs that contain target populations above a certain threshold.

The second step of the analysis framework assesses outcomes of transportation projects, programs, or policies to the general population. This process will differ based on the impact being measured. In the case studies, the process for assessing regional accessibility was highlighted to better understand the methods used in practice for measuring this impact. The final component of quantitative analysis of environmental justice outcomes is evaluating the effect of comparative differences between target populations and reference populations. The typical methods used in the case studies compared the impact on the target areas (however the target populations were defined) to a reference population for equal impacts. In most cases, the case study MPOs followed

the quantitative analysis framework in Figure 15 to evaluate equity of outcomes for the program of projects within their long-range plan.

4.1.3 Case Study Selection

The MPOs selected as the four primary case studies are: Metropolitan Transportation Commission, National Capital Regional Transportation Planning Board, Puget Sound Regional Council, and Boston Region Metropolitan Planning Organization. The case study MPOs were chosen for several reasons. MPOs of comparable population size to the Atlanta Regional Commission were identified using the MPO Database (USDOT n.d) provided by the USDOT. This database reflects data from the 2010 Census and contains information for all existing MPOs. The eight additional MPOs with populations between six million and three million were selected for initial evaluation. Four additional MPOs were identified based on a review of literature and internet resources on metropolitan environmental justice practices and equity assessments as they relate to accessibility. All MPOs identified as potential case studies are listed in Table 10. The planning documents, primarily long-range plans, and other Internet resources were reviewed to answer a set of questions for each of the 12 MPOs. These questions are found in Table 11. The answers provided information on the agency's sustainability priorities, equity assessments, environmental justice processes, and accessibility evaluations. MPOs that expressed equity as a planning objective, had sustainability-focused long-range plans, and/or had equity analyses that differed from the standard environmental justice quantitative analysis were identified as possible case studies. Four MPOs were selected for case studies and four more MPOs were identified as supplemental. This chapter details the long-range planning process, equity evaluations and accessibility analysis of the four primary case studies.

Table 10: MPOs Considered for Case Study Review

MPO	City	State	Population	Size
Atlanta Regional Commission	**Atlanta**	**GA**	**4,819,026**	**4,573**
Metropolitan Transportation Commission	Oakland	CA	7,150,828	7,485
National Capital Regional Transportation Planning Board	Washington DC	DC, MD, VA	4,991,324	3,111
Puget Sound Regional Council	Seattle	WA	3,690,866	6,384
Boston Region MPO	Boston	MA	3,159,512	1,458
Southern California Association of Governments	Los Angeles	CA	18,051,203	38,649
Southeast Michigan COG	Detroit	MI	4,703,593	4,608
Mid-Ohio Regional Planning Commission	Columbus	OH	1,426,183	1,132
San Diego Association of Governments	San Diego	CA	3,095,271	4,260
Houston-Galveston Area Council	Houston	TX	5,892,002	8,466
Delaware Valley Regional Planning Commission	Philadelphia	PA, NJ	5,626,318	3,811
Maricopa Association of Governments	Pheonix	AZ	4,055,281	10,655
Central Lane MPO	Coburg	OR	249,601	124

Table 11: Case Study Screening Questions

Questions for primary review of case studies
Is “equity” included in discussion on sustainability (if there is a sustainability discussion)?
Is “equity” a goal or priority or included in objectives?
Does the agency use environmental justice as their equity assessment?
What environmental justice framework or process do they use? How do they identify target populations? Do they measure accessibility with regards to equity?
How does the agency define and measure accessibility?

4.2 The Atlanta Regional Commission

The Atlanta Regional Commission serves as the MPO for the greater Atlanta region. ARC is among the very large MPOs with over 2.5 million residents. The Atlanta region, as defined by the MPO, has a population over 4.8 million and spans 18 counties, approximately 4,600 square miles. The Atlanta planning region has several other definitions including one for USEPA air quality non-attainment (20 counties), the US Census MSA (28 counties) and the regional commission for the state of Georgia (10

counties). ARC develops the strategic vision for transportation in the MPO region, provides technical support through travel demand modeling and develops and approves the TIP. A detailed discussion of ARC's planning process can be found in Chapter 6.

4.2.1 Long-Range Planning Process

The current long-range comprehensive plan, PLAN 2040, was originally adopted in 2011 and most recently updated in early 2014. The ARC is currently in the process of developing the next long-range regional plan, which has an anticipated completion of spring 2016. The current plan is guided by the purpose, "visionary leadership for sustainable growth by balancing environmental responsibility, economic growth and social needs while maximizing benefits to all," which is supported by articulated objectives and principles. The purpose clearly expresses the triple bottom line of sustainability. A set of five objectives are supported by a set of principles, which together form the official land use policy for the region and guide programming and investment decisions within the Implementation Strategy (ARC 2011a). The program of projects is developed through a process of categorizing, filtering and ranking projects. The final program is also evaluated on a set of performance measures that incorporate MAP-21 National Performance Goals as well as state performance metrics. Impacts of the program of projects are derived from the travel demand model and a future build and future no-build scenario are compared against a base scenario. Table 12 shows the performance measures that were used to compare the current base year performance to a forecasted build and no-build alternative (ARC 2014a).

Table 12: Plan Level Performance Measures for PLAN 2040 March 2014 RTP Update and Results (ARC 2014a)

Performance Emphasis Area	Measure Description	2015 Base		2040 No-Build		2040 Constrained	
Mobility	Average commute travel time by auto / transit (in minutes)	Walk to Transit	58	Walk to Transit	60	Walk to Transit	60
		Drive to Transit	59	Drive to Transit	79	Drive to Transit	77
		Automobile	39	Automobile	61	Automobile	53
Connections / Accessibility	Worker access to employment centers within 45 minutes by car (index)	1.0		0.57		0.77	
	Worker access to employment centers within 45 minutes by transit (index)	1.0		0.87		1.10	
	Average number of jobs within 45 minutes of home for typical person	472,677		308,360		400,015	
Economic Growth	Total congestion cost per person	$1,862		$5,023		$3,900	
	Number of reliable trips in PM peak period	89,065		132,518		215,406	
	Peak period highway VMT	17,377,388		22,146,969		22,044,383	
	Peak period highway speed (mph):	General Lanes : 41 Managed Lanes: 48		General Lanes : 29 Managed Lanes: 41		General Lanes : 32 Managed Lanes: 44	
	Peak Period truck delay (hours)	101,722		419,156		323,544	
Safety	Percent of all regional crashes with an identified PLAN 2040 Update project	-		-		24 %	
	Percent of PLAN 2040 Update projects that intersect above average crash rate facilities	-		-		100 %	

4.2.2 Equity and Accessibility

Equity is not explicitly discussed in the objectives, principles or the performance measures; however accessibility is reflected in the planning goals and performance measures. ARC has goals to promote places with easy access to jobs and services and expand access to community resources, which includes providing reliable transportation alternatives especially to regional centers (ARC 2011a). Accessibility is also a program level performance measure. Access to employment by automobile, transit and walking was evaluated as shown in Table 12. For auto and transit accessibility, PM peak travel time to the regional employment centers was determined based on the base year, 2040 build and 2040 no-build options. Walking accessibility was evaluated based on potential demand. This was measured by the intersection grid and the number of households,

services and retail jobs a person could walk to. A multimodal accessibility measure was also created that provided a composite understanding of access to employment by all three modes within a 45-minute transit trip, a 30-minute drive or a 15-minute walk (ARC 2014a).

Despite the absence of equity in the objectives and performance measures, ARC was active in the arena of procedural equity while developing PLAN 2040 and had a Community Engagement Plan, Social Equity Advisory Committee, focus groups and listening sessions (ARC n.d.). Furthermore, environmental justice assessments for the planning scenarios were conducted through an Equitable Target Area Analysis, as described below.

The ARC evaluates equity within the context of environmental justice. It follows a process that identifies Equitable Target Areas (ETA) and compares impacts for these areas to the region. The 2015 ETAs are defined based on poverty and race. To develop the demographic profile, the concentration of households in poverty, and the African-American, Asian, Hispanic, and other non-white race populations for each census tract were determined. The standard deviations for each of these demographic segments (excluding the outliers) were used to create categories. A census tract was considered Category 1 if its percentage exceeded the highest standard deviation, Category 2 if it was between the second highest and highest standard deviation and Category 3 if it was below the second highest standard deviation. ETAs were defined as any tract that fell into Category 1 or 2 for poverty. Minority population categories were then used in distinguishing between very high and high in the ETA Index. Figure 16 shows the current ETAs being used for the plan update. Very High ETAs are tracts with both poverty and minority populations in Category 1. A High ETA index reflects tracts with poverty in Category 1 but minority populations in Category 2 or lower. Finally, Medium level ETAs are tracts with poverty in Category 2, regardless of minority population.

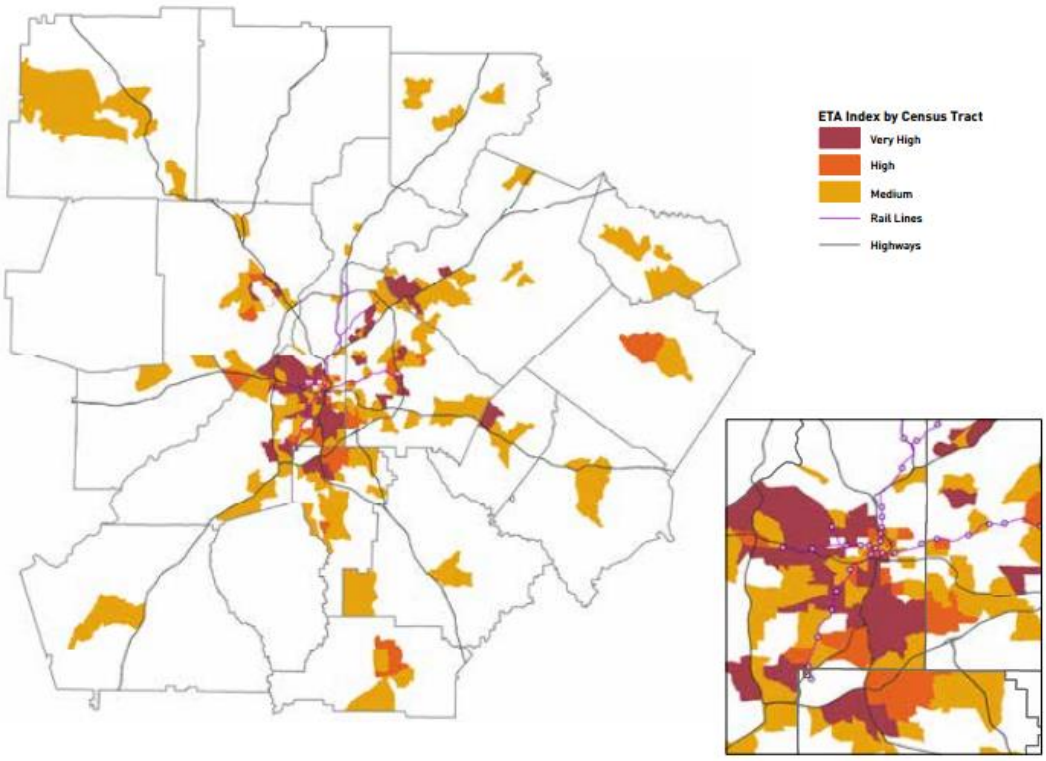


Figure 16 ARC Equitable Target Areas for 2016 Plan Update (ARC 2014b)

The ETAs were historically used to identify if projects were planned in the areas by determining what percentage of the projects were planned relative to the percent of the population. Travel demand model results were also used to evaluate the changes in impacts for ETAs. A new process is being used in the updated plan. There is a focus on accessibility using Open Trip Planner transit data to determine the base year accessibility in environmental justice areas. This information supported the technical assessment. Using open trip planner and ladders of opportunity, the definition of accessibility is moving from travel time to work to a more opportunities-based evaluation. The ladders of opportunities identify hospitals, libraries, colleges, public and private schools within a 60 minute transit trip, and grocery stores within a 30 minute transit trip. Also, ARC is incorporating ETAs into other decision-making processes such as in-depth neighborhood studies led by the Poverty Committee and project evaluation analyses.

4.3 Metropolitan Transportation Commission

4.3.1 Long-Range Planning Process

The Metropolitan Transportation Commission (MTC) is the regional planning, coordinating and financing agency for transportation in the San Francisco Bay area. The nine-county area comprises over seven million residents in about 7,500 square miles (MTC 2015). The current long-range plan, *Plan Bay Area*, was approved in the summer of 2013 with a 2040 planning horizon. It is the comprehensive transportation and land use plan for the region and the process for developing it was performance based. Performance measurement has been used in driving MTC's long-range planning since 2001 but the previous plan, *Transportation 2035*, was considered the MPO's first "performance-based" plan (FHWA 2013). Figure 18 depicts its development.

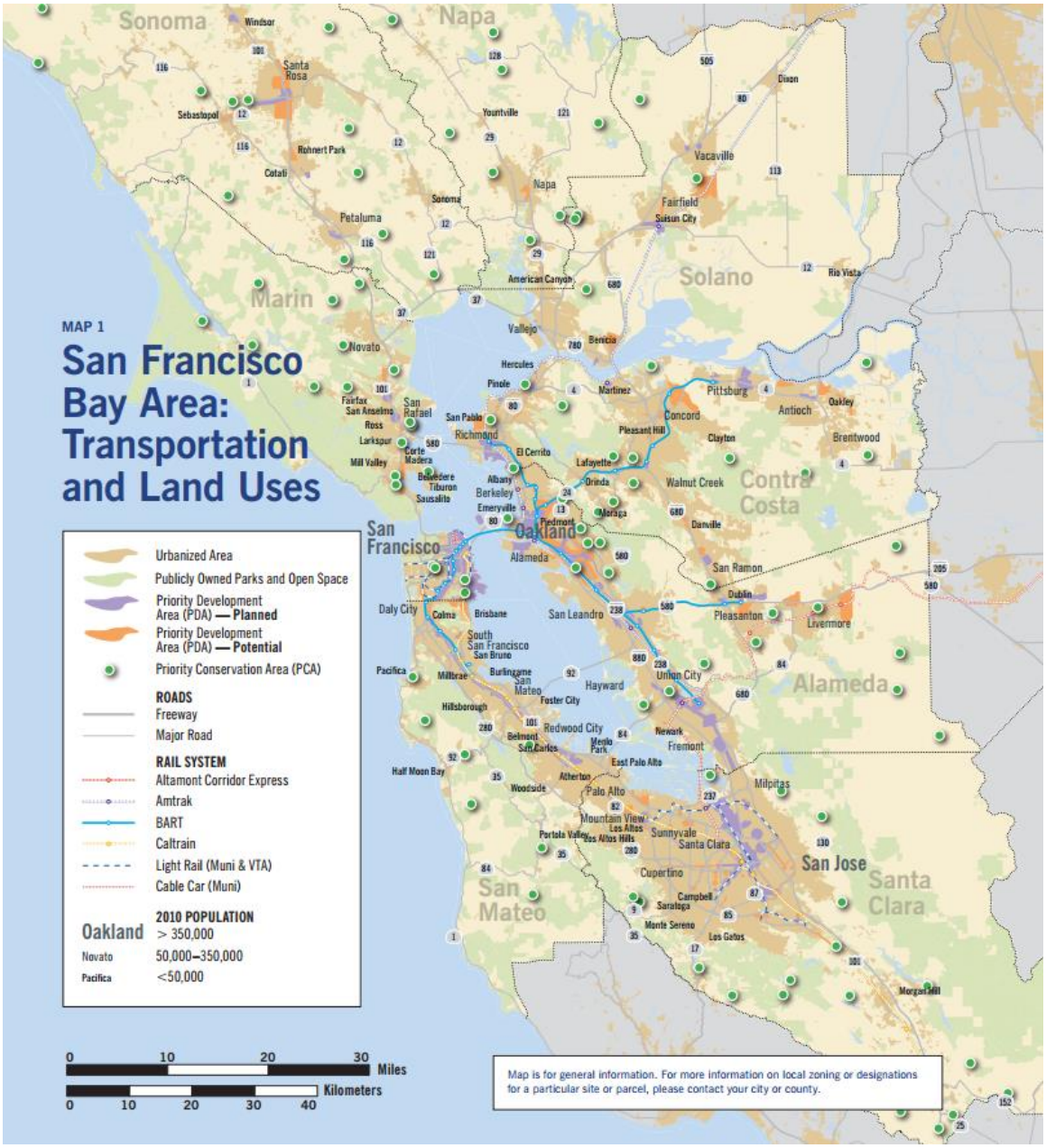


Figure 17 San Francisco Bay Area and Metropolitan Transportation Commission Planning Area (MTC 2013a)

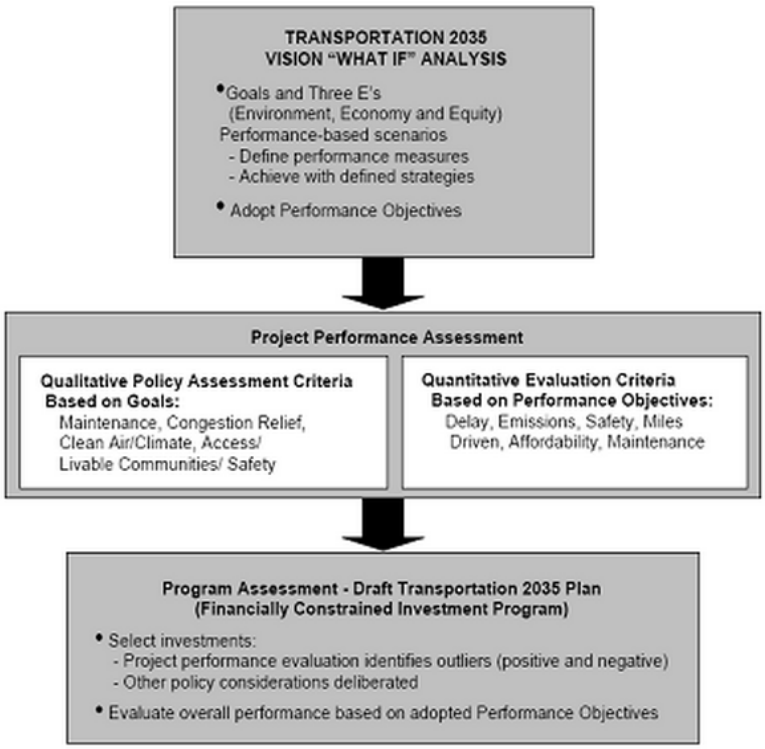


Figure 18 Development of "Transportation 2035," MTC's first performance-based long-range plan (FHWA 2013).

The development process for the current plan, *Plan Bay Area*, followed a similar process and reflects the performance management process outlined in Figure 14. Performance targets were established based on regional goals. A set of visioning scenarios coupled with different land use and transportation investments to support the goals and these visioning scenarios were evaluated based on how well each scenario met the performance targets. The scenarios were then refined by evaluating high and low performers at the project level and a short list of alternative scenarios was chosen. The alternative scenarios were subject to a comparative evaluation to determine which alternative best supported the long-range planning goals, similar to the feedback loop in Figure 14. The preferred scenario was then included in *Plan Bay Area* as the TIP. The MTC planning process is outlined in Figure 19.

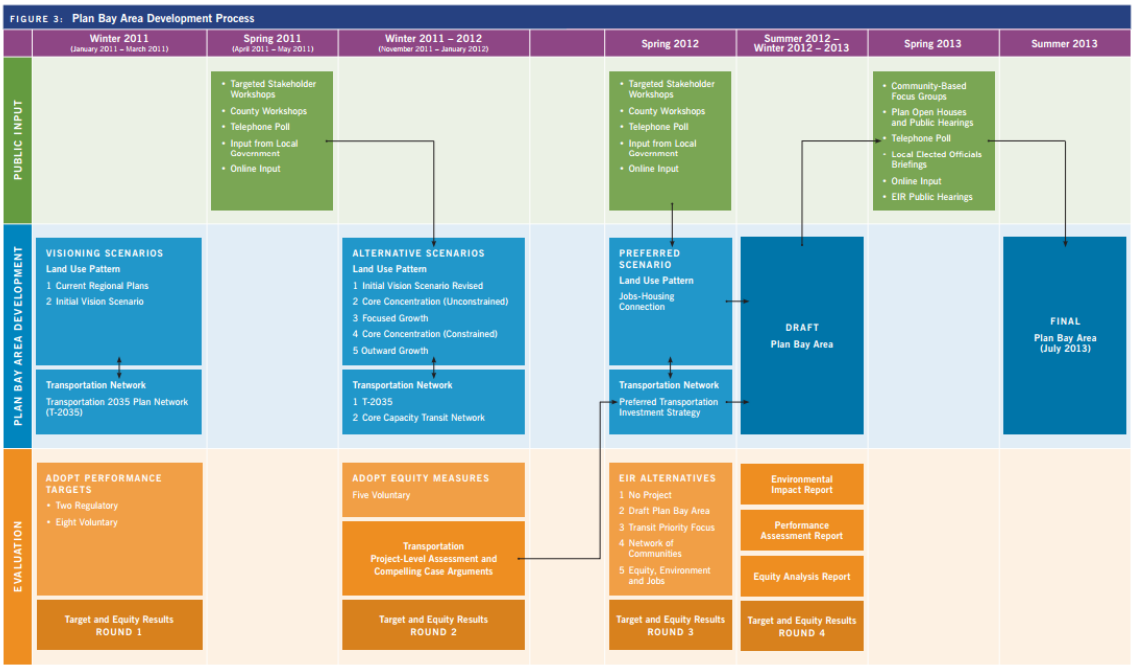


Figure 19 Development process for MTC's long-range plan "Plan Bay Area" (MTC 2013a)

The performance targets used to guide the planning process were adopted in the beginning of 2011. The desired performance outcomes were based on the fundamental goal of sustainability and integrating the three Es (environment, equity and economy). Population, employment and housing forecasts were used to project the future needs and provide a basis for regional land use plan. The transportation network from *Transportation 2035* was used as the initial scenario. Stakeholder and community feedback led to a set of five alternative scenarios better equipped to meet the ten performance targets in Figure 20. The scenarios were then subject to a project-level assessment of the performance and cost-effectiveness of the region's largest transportation investments. Projects are evaluated based on their benefit-cost ratio, their ability to support the performance targets and whether or not they serve a target population. Low performers (with benefit-cost ratios of less than 1 or adverse effects on the performance targets) were still included in the plan if they were able to demonstrate positive effects on social equity and low-income neighborhoods.

Approximately 900 projects were scored and ranked based on the comprehensive vision for regional transportation. By incorporating performance into the program development process and linking it to goals and important issues for the region, there was

a significant change in comparison to past processes. Typically highway projects would rank the highest; however, now projects such as infill transit and others that serve the core of the region tend to rank highest (Kirkey 2015). The project evaluation includes both quantitative and qualitative assessments of social equity objectives to address regional equity goals (Johnson 2015). The project-level assessment step led to the determination of a preferred scenario to be included in *Plan Bay Area* as the TIP. The preferred scenario and the five alternative scenarios were tested for the ability to meet the targets, two of which were mandatory. The performance of the long-range plan is analyzed and summarized in the *Performance Assessment Report* (MTC 2013b).

The adopted *Plan Bay Area* meets some of the 10 performance targets (and 5 sub-targets) as shown in Figure 20. It meets or exceeds 6 targets, is slightly below on 3 targets and misses 2. It moves in the opposite direction on the remaining four targets. One of these targets is to "decrease by 10 percentage points (to 56 percent from 66 percent) the share of low-income and lower-middle income residents' household income consumed by transportation and housing." The share is projected to increase to 69 percent. The targets that are not achieved highlight areas of needs and are taken as a call to action and MTC supports improvements in these areas through coordination with other agencies (e.g. for land use considerations) and strategies such as using discretionary funding programs (e.g. affordable housing programs) (Johnson 2015).

Summary of Performance

TABLE 25: Results of Plan Bay Area Target Assessment

Plan Meets or Exceeds Target			
Climate Protection	**Target #1:** Reduce per-capita CO_2 emissions from cars and light-duty trucks by 15 percent.	Plan meets and exceeds target; reduces per-capita emissions of CO_2 by 18 percent (by 2040).	
Adequate Housing	**Target #2:** House 100 percent of the region's projected growth by income level (very-low, low, moderate, above-moderate) without displacing current low-income residents.	Plan meets target; houses 100 percent of population growth.	
Healthy and Safe Communities Reduce Particulate Matter	**Target #3a:** Reduce premature deaths from exposure to fine particulates ($PM_{2.5}$) by 10 percent.	Plan meets and exceeds target; reduces premature deaths from exposure to fine particulates by 71 percent.	
	Target #3c: Achieve greater reductions in highly impacted areas.	Plan meets target; achieves greater particulate emission reductions in highly impacted neighborhoods.	
Open Space and Agricultural Land	**Target #6:** Direct all non-agricultural development within the year 2010 urban footprint (existing urban development and urban growth boundaries).	Plan meets target; directs all non-agricultural development within the existing urban footprint.	
Economic Vitality	**Target #8:** Increase gross regional product (GRP) by 110 percent — an average annual growth rate of approximately 2 percent (in current dollars).	Plan meets and exceeds the economic growth target; 119 percent increase in GRP is forecasted over the life of the plan.	
Plan Makes Progress Toward Target			
Healthy and Safe Communities Reduce Particulate Matter	**Target #3b:** Reduce coarse particulate emissions (PM_{10}) by 30 percent.	Plan reduces coarse particulate emissions by 17 percent, but falls short of target.	
Active Transport	**Target #5:** Increase the average daily time walking or biking per person for transportation by 70 percent (for an average of 15 minutes per person per day).	Plan boosts per-person active transportation by 17 percent, but falls short of target.	
Transportation System Effectiveness Increase Non-Auto Mode Share	**Target #9a:** Increase non-auto mode share by 10 percentage points (to 26 percent of trips).	Plan boosts non-auto mode share to 20 percent of trips, but falls short of target.	
Reduce VMT per Capita	**Target #9b:** Decrease automobile vehicle miles traveled (VMT) per capita by 10 percent.	Plan reduces VMT per capita by 9 percent, but falls short of target.	
Local Road Maintenance	**Target #10a:** Increase local road pavement condition index (PCI) to 75 or better.	Plan improves pavement condition of local roads to a PCI of 68, but falls short of target.	
Plan Moves in Opposite Direction From Target			
Reduce Injuries and Fatalities from Collisions	**Target #4:** Reduce by 50 percent the number of injuries and fatalities from all collisions (including bike and pedestrian).	Plan moves in opposite direction from target; injury and fatality collisions are projected to increase during plan period by 18 percent.	
Equitable Access	**Target #7:** Decrease by 10 percentage points (to 56 percent from 66 percent) the share of low-income and lower-middle income residents' household income consumed by transportation and housing.	Plan moves in wrong direction; the share of household income needed to cover transportation and housing costs is projected to rise to 69 percent for low-income and lower-middle income residents during the Plan Bay Area period.	
Transportation System Effectiveness Highway Maintenance	**Target #10b:** Decrease distressed lane-miles of state highways to less than 10 percent of total lane-miles.	Plan moves in opposite direction from target; the percentage of distressed state highway lane-miles in the region will rise to 44 percent of the regional highway system by year 2040.	
Transit Maintenance	**Target #10c:** Reduce the share of transit assets past their useful life to 0 percent.	Plan moves in opposite direction from target; the share of transit assets past their useful life is projected to increase to 24 percent of all assets during the Plan Bay Area period.	

Figure 20 Summary of "Plan Bay Area" performance (MTC 2013a)

4.3.2 Equity and Accessibility

Although the plan fails to meet its equity performance target, MTC identifies "achieving equity in the long-range planning process" as a key element of the performance-based approach. In addition to the 10 performance targets, there is a set of

equity measures used in the *Equity Analysis Report* (MTC 2013c) for the Bay Area that are evaluated concurrently. The *Equity Analysis Report* summarizes the work conducted throughout each phase of the planning process and the assessment of five quantitative measures related to equity concerns: housing and transportation affordability, potential for displacement, healthy communities, access to jobs and equitable mobility (Table 13).

Table 13: Equity Performance Measures for "Plan Bay Area" (MTC 2013a)

TABLE 5: Plan Bay Area Equity Performance Measures		
	Equity Issue	**Performance Measure**
1	**Housing and Transportation Affordability**	% of income spent on housing and transportation by low-income households
2	**Potential for Displacement**	% of rent-burdened households in high-growth areas
3	**Healthy Communities**	Average daily vehicle miles traveled per populated square mile within 1,000 feet of heavily used roadways
4	**Access to Jobs**	Average travel time in minutes for commute trips
5	**Equitable Mobility**	Average travel time in minutes for non-work-based trips

The *Equity Analysis Report* outlines the results of the analysis for the *Plan Bay Area* Equity Performance Measures, which is a separate but complementary equity effort to Title VI and environmental justice federal requirements. The *Equity Analysis Report* evaluates the outcomes of the program relative to the five equity performance measures and also examines the financial and spatial distribution of project investments across the region. MTC follows the commonly used equity analysis process (Figure 15), identifying the target population spatially and then evaluating the impacts in target areas. MTC refers to the target areas as communities of concern.

The Bay Area's traffic analysis zones (TAZs) are classified as communities of concern based on the demographic composition of the residents. Areas are considered communities of concern if they have a significant concentration of four or more of the following: minority residents, low-income individuals, persons with limited English proficiency, individuals 75 years or older, zero-car households, single-parent households, persons with disabilities, and renters paying more than 50 percent of household income on rent. The definition of communities of concern used in *Transportation 2035* included only areas with 70% minority or 30% low-income residents, but feedback from that

planning cycle suggested the inclusion of additional target populations to provide a more focused definition. Apprehension that the coverage of *Transportation 2035*'s definition would make analysis difficult to interpret for a region that is "majority-minority" and has an increasing number of minority residents led to the inclusion of the additional target populations. Most of the TAZs identified by the new definition were also captured by the old definition (MTC 2013c).

As mentioned, TAZs with high concentrations of four or more target populations are considered communities of concern. A TAZ is also identified as a community of concern if it has high concentrations of both minority and low-income residents, even without other target populations. The thresholds established for "high/significant" concentration of these populations are between the regional average and one standard deviation above the mean as shown in Table 14.

Table 14: Target Populations and Thresholds for MTC Communities of Concern (MTC 2013c)

Disadvantage Factor	% of Regional Population	Concentration Threshold
1. Minority Population	54%	70%
2. Low Income (<200% of Poverty) Population	23%	30%
3. Limited English Proficiency Population	9%	20%
4. Zero-Vehicle Households	9%	10%
5. Seniors Aged 75 and Over	6%	10%
6. Population with a Disability	18%	25%
7. Single-Parent Families	14%	20%
8. Rent-Burdened Households	10%	15%

After the communities of concern are identified, the performance of the TAZs categorized as such is assessed in the five equity performance areas. For each alternative programming scenario the performance metrics are estimated and the results are compared on two points to assess disproportionality. The first point is whether the plan's forecasted results have positive impacts on communities of concern in comparison to the base year. For *Plan Bay Area*, the estimated impacts in the equity performance areas were compared between the base year 2010 and each forecasted scenario to determine the direction and magnitude of trends. The second point is whether communities of concern and other parts of the region are impacted similarly. To do this, the plan compares the

difference in impact between the 2040 no-build forecast and the preferred scenario (Draft Plan) for the communities of concern and the remainder of the region.

Accessibility for target populations is covered in the performance measures related to job access and equitable mobility. Access to jobs is measured based on commute time, and travel time for all other trips is used as the measure for equitable mobility. The travel time for both commute and non-mandatory trips is derived from the activity-based travel demand model for the region. Average travel times for communities of concern are compared across the program alternatives and also between the target populations and the remainder of the region (Table 15).

Table 15: Average Travel Times for MTC target and reference areas (MTC 2013a)

Measure	Target Population	2010	1	2	3	4	5	% Change	
		Base Year	No Project	Draft Plan (Project)	Transit Priority Focus	Network of Comm.	Env., Equity & Jobs	Base Year to Project	No Project to Project
Average Commute Time	Communities of Concern	25	26	26	25	26	25	5%	-1%
	Remainder of Region	27	29	27	26	27	27	2%	-6%
Average Non-Commute Time	Communities of Concern	12	13	13	13	13	13	5%	0%
	Remainder of Region	13	13	13	13	13	13	1%	0%

The results of the equity analysis are used to comply with environmental justice and Title VI requirements. The environmental justice analysis focuses on the comparison of communities of concern to the remainder of the region. All transportation investments were mapped across the region to assess the spatial distribution of projects between communities of concern and the remainder of the region. Additionally, within the *Equity Analysis Report*, there is a Transportation Investment Analysis section that compares the level of investment for the aggregation of minority and low-income populations with regard to their transportation use and population shares in the Bay Area. Title VI Analysis uses this information and focuses on transit benefits for minority transit riders.

In the end, the plan scenarios are evaluated for their ability to reduce disparities between communities of concern and the remainder of the region, comparing the differences between communities of concern and the remainder of the region for the base year and the forecasted plan scenarios. Actual disparities can be tracked using MTC's Snapshot Analysis that is designed to measure and track transportation-related indicators

for communities of concern (MTC n.d.). This analysis was developed in 2010 and tracks performance on selected transportation-related indicators for communities of concern over time to demonstrate the outcomes of investments across planning cycles. It is the result of a recommendation from the previous planning cycle and is based on MTC's performance-based approach to planning. Although Snapshot is not currently updated, MTC expects to renew the analysis in the next 18 months to provide regional data and trends.

A key finding from the MTC case study review relates to the benefits of prioritizing equity. Of the four case studies, MTC has one of the most well-documented processes for including equity in the planning process and also does a superior job of incorporating equity considerations into the planning process. MTC formally includes equity as a priority in the long-range planning process and as a result, they incorporate equity considerations into the program evaluation by using an equity measure in their primary performance measures and by conducting further equity analyses to evaluate program scenarios. It should be noted that the adopted plan did not meet all the performance targets; however, MTC has established additional analyses such as the Snapshot Analysis to evaluate disparities over planning cycles and continues to support discretionary funding programs to address key transportation issues in Communities of Concern such as the Lifeline Program and Community Based Transportation Planning grants.

4.4 National Capital Region Transportation Planning Board

4.4.1 Long-Range Planning Process

The National Capital Region Transportation Planning Board (TPB) is organized under the Metropolitan Washington Council of Governments (MWCOG) and oversees transportation planning in the Washington DC metropolitan area as the MPO. The area is home to over 5.3 million residents and spans approximately 3,500 square miles, including four counties in Maryland, four counties in Virginia, and the District (Figure 25) (NCRTPB 2014a). The trans-jurisdictional nature of the MPO leads to coordination

between the District Department of Transportation, Maryland Department of Transportation, and Virginia Department of Transportation. These three entities have their own funding streams and processes for project development and identify projects through state-level long-range planning. Additionally, the TPB has 12 cities and 8 counties as member jurisdictions as well as the regional transit agencies, including Washington Metropolitan Area Transit Authority, which identify and fund their own transportation projects. Although the TPB may identify additional projects through technical analyses that it conducts at the regional level, the TPB's primary responsibility is the long-range transportation plan and the approval of the TIP. The TPB does not allocate funding, prioritize or select projects, nor implement transportation improvements; however, it has influence on the types of projects that are programmed since it comprehensively reviews the regional system and the interaction between the components (NCRTPB n.d.) and sets goals and objectives for regional transportation (Klancher 2015).

The *Regional Transportation Priorities Plan* (RTPP), approved in January 2014, outlines strategies to address significant transportation challenges in the Capital region. It serves as a policy framework to guide the MPO and the local and state leaders in the identification of transportation improvements; it informs the development of the *Constrained Long-Range Transportation Plan* (CLRP). The RTPP supports the goals of MWCOG's comprehensive plan, *Region Forward*, and outlines goals, objectives and strategies for developing the regional transportation system. The broad goals of the RTPP lead to three regional priorities (Figure 21) and a set of supporting strategies. The second priority in the RTPP is to "strengthen public confidence and ensure fairness," which is closely related to environmental justice and equity in general and is supported by strategies such as ensuring accessibility for traditionally disadvantaged groups including persons with disabilities, low incomes and limited English proficiency. There are various implementation suggestions to achieve this, including expanding transit

service, limiting negative effects of fare increases, and providing information in multiple languages and formats (NCRTPB 2014a).

Figure 21 Three regional priorities outlined in the "RTPP" (NCRTPB 2014a)

The RTPP is the policy framework for planning in the Capital region and the CLRP is one component of its implementation, along with the TIP and other state and local programs and regional initiatives (Figure 22). The CLRP is the financially-feasible compilation of projects for the time horizon of 25 years and was most recently updated in 2014. The program of projects in the CLRP is assessed in relation to the RTPP in a document called the *Priorities Plan Assessment*. The CLRP *Priorities Plan Assessment* provides a qualitative evaluation of how the CLRP meets the regional transportation goals asserted in the RTPP and supports a directive of the RTPP to "undertake efforts to evaluate how well the projects and programs in the CLRP, taken as a whole, support regional priorities" (NCRTPB 2014, pg. 1). The *Priorities Plan Assessment* uses information from the supporting technical evaluations (the Performance Analysis, the Financial Analysis, and the Cooperative Land-Use Forecast) and professional judgment

to answer two questions for each of the strategies that are related to the three regional priorities:

- What does the CLRP tell us?
- What is the basis for this assessment?

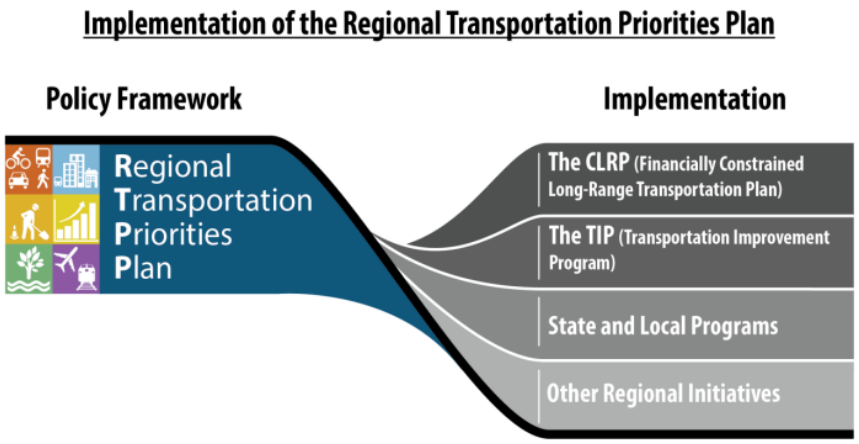


Figure 22 Implementation pathways for the TPB regional strategic plan (NCRTPB 2014b)

Projects are not specifically identified or evaluated in the *Priorities Plan Assessment* and the assessment does not affect approval of the CLRP and TIP; rather the report provides a high level estimation of how the priorities may be met through the CLRP. This suggests that a foundation has been created for performance management by tying the projects in the CLRP to regional priorities in the RTPP, yet there is opportunity for progress, especially in evaluating how projects relate to regional goals.

4.4.2 Equity and Accessibility

The CLRP is also analyzed for its impact on minority and transportation disadvantaged population groups through an environmental justice evaluation. The environmental justice evaluation has three components, a demographic profile, a travel characteristics analysis and an evaluation of changes in accessibility (NCRTPB 2014c), similar to the three steps of the environmental justice analysis process in Figure 15. Unlike typical environmental justice analysis, however, TPB does not use thresholds or

target areas to assess impacts such as accessibility. TPB creates demographic profiles of the region to identify the geographic distribution of target populations (African-American, Asian American, Hispanic, low-income, disabled, limited English proficiency and elderly populations), and uses the profiles to evaluate the distribution of investment by mapping major highway, HOV and transit improvements in relation to target populations. This process is similar to other environmental justice evaluations. TPB identified a limitation of their process that is consistent across the other cases as well: forecasting location and other characteristics of target populations (Klancher 2015). In the TPB analysis, it is assumed that the demographic profiles will not change over the planning horizon.

The travel characteristics analysis identifies the commute mode for the target populations based on ACS data and the demographic profile is used to determine the proximity of these demographic groups to existing and planned transit for a comparison. The final component of the TPB environmental justice process is an analysis of accessibility included in the *Performance Analysis*. Accessibility is defined as the number of jobs within a 45-minute commute via automobile and transit (NCRTPB 2014d). The results are taken in aggregate for each demographic group and the total regional population. The change in access for each group between the base year 2010 and forecast year 2040 is compared across all populations (Figure 23). The environmental justice process as it has been outlined is the main approach for addressing equity by the TPB.

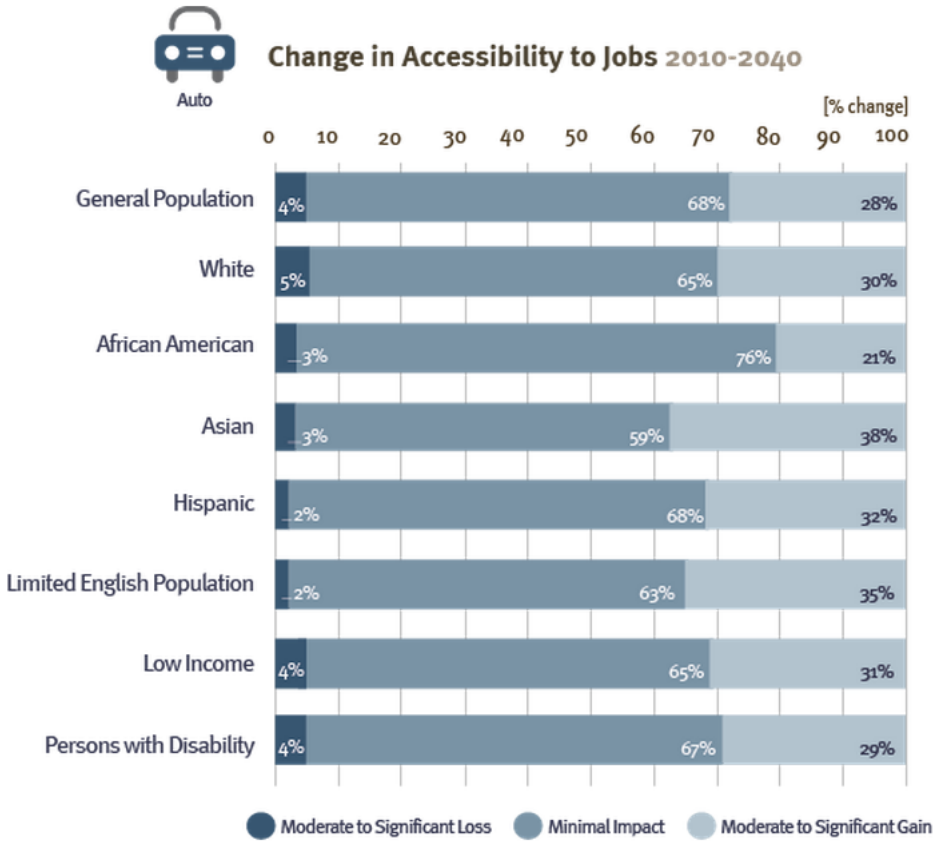


Figure 23 Forecasted change in job accessibility via automobile across demographic groups for the TPB planning area (NCRTPB 2014e)

The TPB case exemplifies the complications of equity evaluations. The environmental justice evaluation of accessibility in the CLRP concludes that there are not disproportionate effects and that gains and losses are similar across all population groups for both modes evaluated (auto and transit). The maps published by TPB and shown in Figure 24 and Figure 25 tell more of the story. The areas of greatest loss in access are concentrated in areas of high minority populations and in areas where the percent of households considered low-income exceeds the regional average. This is not reflected when looking at the results on the aggregate and highlights the importance of the spatial distribution of impacts and how spatial information works in concert with the demographic distribution. In general, it supports the assertion that the equity evaluation should not be conducted to determine whether there is or is not equity, but to provide

information that identifies equity considerations and is useful to improve decision making for equitable outcomes.

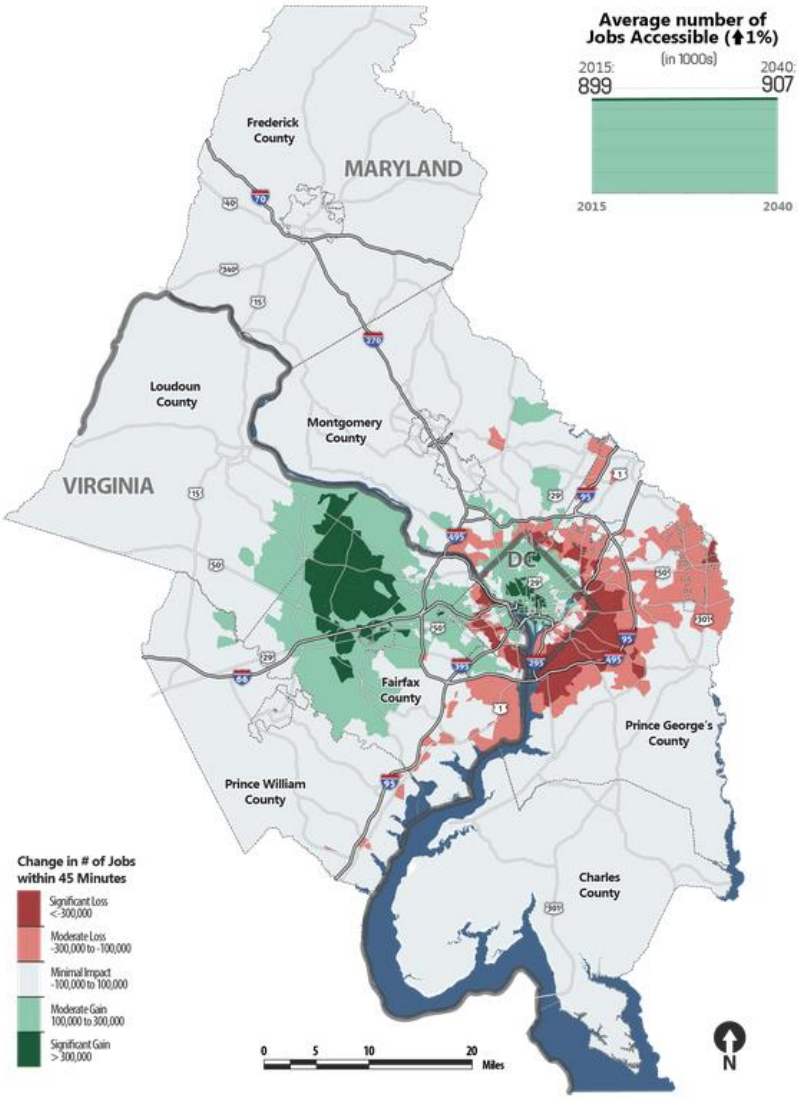


Figure 24 The change in job accessibility in the TPB planning area forecasted for 2040 (NCRTPB 2014d)

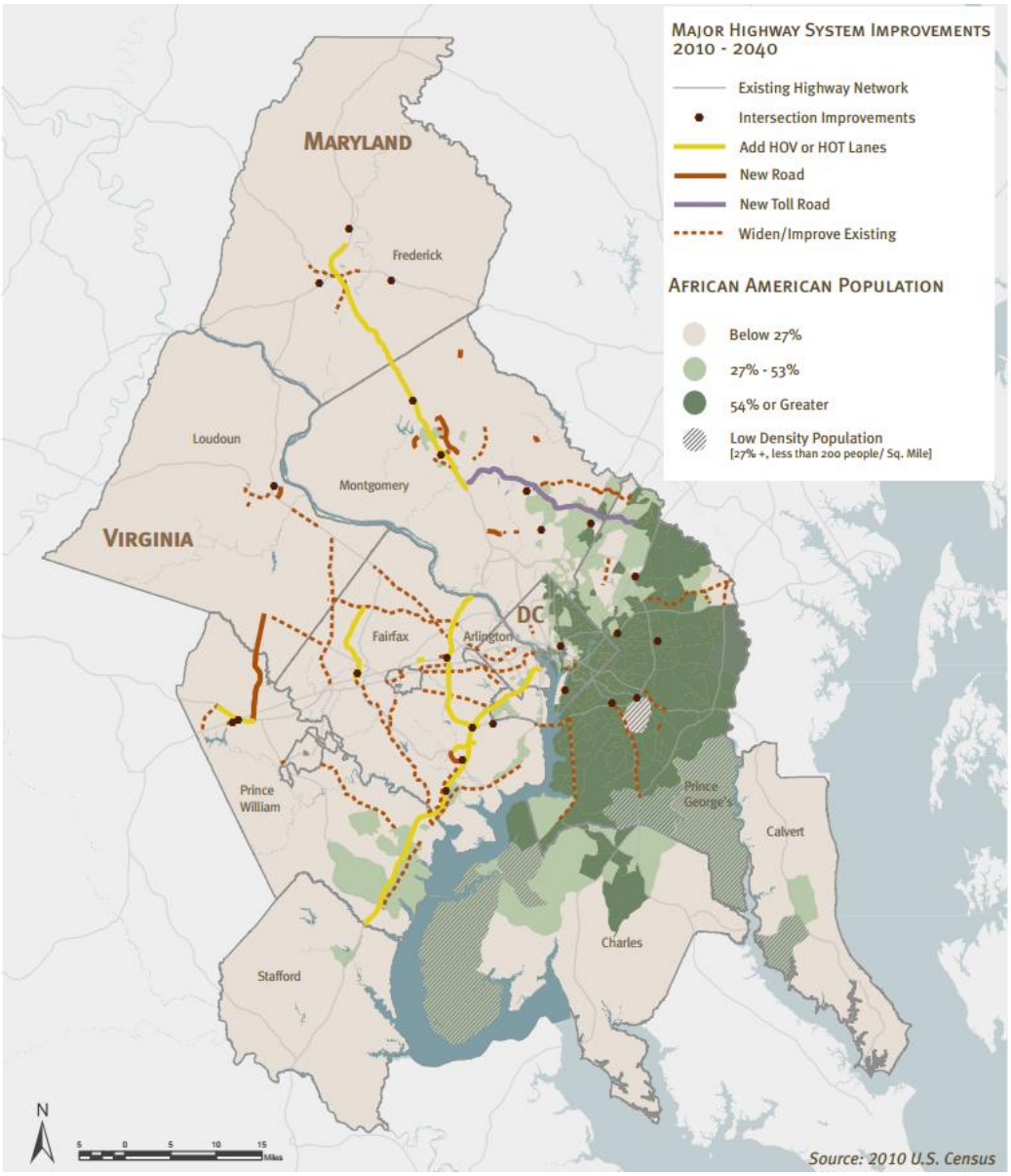


Figure 25 Major highway system improvements and the African-American population in the TPB planning area (NCRTPB 2014f)

4.5 Puget Sound Regional Council

4.5.1 Long-Range Planning Process

The Puget Sound Regional Council is responsible for comprehensive planning in the Seattle, Washington metropolitan area. The area has a population just fewer than 3.7 million people within four counties spanning about 6,400 square miles (Figure 26) (PSRC 2008). Comprehensive planning for the region is guided by *Vision 2040*, the strategic regional plan, adopted in 2008 to establish a common vision for the future of the region. The central theme of *Vision 2040* is the triple bottom line of sustainability, "people, prosperity and planet." Under the broad goal of sustainability, the regional planning framework establishes six policy goal categories. The six goal categories can be found in Figure 27. Within each of these categories, there are policies, actions and measures. The policies in each of the categories direct land use, economic development, environmental, transportation and other infrastructure planning across the four counties of the region, producing a common framework for planning at various levels (e.g. county, local, transit operator, etc.). Additionally, the policies provide the structure for the functional plans, the Regional Economic Strategy and the Metropolitan Transportation Plan (PSRC 2008).

Figure 26 Puget Sound Regional Commission planning area (PSRC 2008)

Figure 27 Policy structure for comprehensive planning for PSRC as described in Vision 2040 (PSRC 2008)

The Metropolitan Transportation Plan, titled *Transportation 2040*, provides the long-range vision for transportation in the Seattle metropolitan area and the strategy to attain it. It was adopted in 2010 and updated in 2014 and supports *Vision 2040* to achieve regional sustainability goals related to transportation. Figure 28 shows the framework for developing *Transportation 2040*. The policies and measures of *Vision 2040* are at the center of the process. Prioritization of projects in the transportation plan is influenced by issues identified at the state, regional, and local level and the evaluation measures of the prioritization are based on the policies in *Vision 2040*. Once the projects are funded and implemented, they are monitored at the program level for their performance relative to the planning goals. The findings are then used to identify issues that feeds back into the cycle. This generally follows the metropolitan planning process in Figure 13.

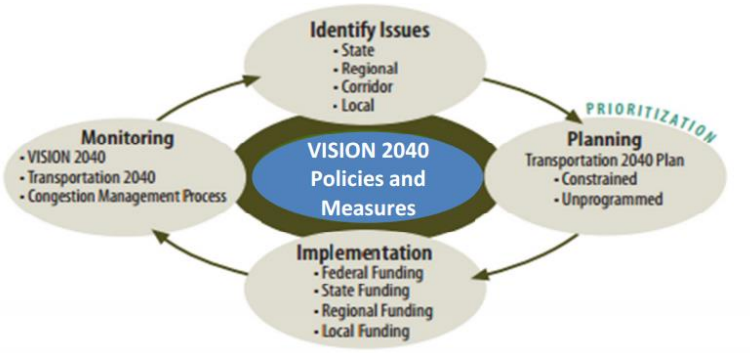


Figure 28 Framework for PSRC long-range plan "Transportation 2040" (PSRC 2010a)

Transportation 2040 was updated in 2014 using a framework for project evaluation that was generated by a working group and regional staff and was approved by PSRC boards. The framework uses nine evaluation measures (based on *Vision 2040* and *Transportation 2040* goals and policies) to assess projects' ability to implement regional goals in order to prioritize the unconstrained project list for the long-range plan. Each evaluation measure has an associated scorecard that provides a numeric point assignment that reflects the level of benefit each project is estimated to produce. This suggests a way to incorporate benefits of transportation improvements into the project prioritization process. The scorecard for the measure Social Equity and Access to Opportunity is shown in Table 16.

Table 16: PSRC Scorecard for Social Equity and Access to Opportunity (PSRC 2010a)

	Purpose: Improve environmental health. How well does the project avoid creating new, mitigate existing, or eliminate previous negative impacts for the following populations: minority, low-income, elderly, youth, people with disabilities, and households without vehicles.		
Points	2		The project avoids creating new negative environmental health impacts or physical barriers for these populations[17]
	Choose one	4	The project improves environmental health for three or more of these populations
		3	The project improves environmental health for two of these populations
		2	The project improves environmental health for one of these populations
	Purpose: Improve access to opportunity. How well does the project improve access to areas of opportunity?		
	Choose one	4	The project improves access[18] to an area with a low ranking for opportunity and connects it with an area with a high ranking for opportunity (as defined by the Growing Transit Communities opportunity mapping[19]).
		2	The project improves access to an area with a low ranking for opportunity (as defined by the Growing Transit Communities opportunity mapping).
		1	The project improves access to an area with a high ranking for opportunity (as defined by the Growing Transit Communities opportunity mapping).
Total	10 (max)		

4.5.2 Equity, Project Selection and Environmental Justice

The scorecard for Social Equity and Access to Opportunity assigns points for improving the environmental health of target populations. Points are also assigned to projects that improve access to opportunity relative to the ranking of the area. This ranking is discussed later. Scorecards are also used to prioritize projects based on other evaluation measures including Air Quality, Freight, Jobs, Multi-modal, Puget Sound Land and Water, Safety and System Security, Support for Centers, and Travel.

Projects are categorized into one of four investment types: Regional System Expansion, Local Projects, Programmatic, and State of Good Repair. Table 17 explains these categories further along with anticipated funding based on financial strategy for the 30 years of the plan. Projects in the system expansion category are subject to prioritization using the evaluation measures. Projects that fall into this category are

organized by the type of facility they will expand, Arterials, Bicycle/Pedestrian, Highways, or Transit, and relative project rankings are established for projects in each infrastructure category. At the regional scale, the geographic distribution of benefits and costs across six different regional growth areas (e.g. larger cities, unincorporated UGA, rural, etc.) is then cross-checked with the Regional Growth Strategy to identify geographies that do not align in terms of the distribution of projects, costs, or benefits.

Table 17: Investment Categories and Funding Levels for Transportation 2040 (PSRC 2010a)

Regional System Expansion $ 65 Billion	Includes investments in highways, arterials, transit, and bicycle/pedestrian facilities. This category also includes investments in existing and future transit capital as well as auto ferry capital costs.
Local Projects $ 20 Billion	This category includes investments in local transit, streets, and arterials as identified in local comprehensive plans.
Programmatic $ 7 Billion	This category includes investments in demand management, intelligent transportation systems, traffic operations, and passenger ferries.
State of Good Repair $ 81 Billion	Includes estimation of state, local government, and transit agency investment in Preservation, Maintenance, and Operation. This category also includes existing and future transit service cost.
Total $ 173 Billion	**Total investment in the Constained portion of T2040**

The PSRC prioritization process for Regional System Expansion projects boasts the ability to assess tradeoffs more effectively. The scorecards allow projects to be sorted and ranked not only based on the overall anticipated benefits, but also by project status, timeframe and on individual benefits (from the evaluation measures) to better understand how the projects compare across various criteria (PSRC 2010a).

The projects that fall into the other categories do not use the scorecards. These projects are often prioritized outside of PSRC and are not subject to regional-level evaluation. However, some types of projects (e.g. the transit program) have regional coordination that involves input from PRSC. Programmatic projects are also are reviewed by staff (on the regional scale, not the project scale) to ensure that they align

with regional policy before they are included in the financially-constrained, four-year TIP. Some programmatic projects are also reviewed by a PSRC advisory board to evaluate how policy investments meet the regional goals.

This project prioritization evaluation method was employed for the first time in the 2014 plan update; however, because it was not a major update and did not produce a new plan, project scenarios were not evaluated and it was not subject to another NEPA process (Scrivner 2015). In the original development of the long-range plan adopted in 2010, after PSRC created investment scenarios for financially constrained programs of projects, the programs were subjected to additional evaluation including environmental justice assessments (Scrivner 2015). Environmental justice is used as a criterion for evaluation of regional project investment scenarios in the NEPA FEIS process. The FEIS addresses environmental justice in four ways:

1. The geographic distribution of benefits and burdens by county and county subarea,
2. The distribution of benefits and burdens by income groups,
3. The distribution of benefits to freight and passenger vehicles, and
4. An accounting and comparison of investment benefits to minority and low-income residents (PSRC 2010b).

Alternative program scenarios are compared based on potential impacts (noise, air quality, land use, employment, etc.). The estimated benefits (in dollars) are compared for environmental justice populations across all scenarios in the four ways outlined. The impacts from the alternative scenarios are compared to determine which one yields the highest benefit with consideration of environmental justice populations.

Similar to standard practices, environmental justice areas are defined based on a threshold of environmental justice populations. Environmental justice populations are identified as minority (Black, Hispanic, Asian, American Indian, or Pacific Islander) and low-income (households with incomes of 1.99 times the poverty line and below). The

percentage of each of these populations within a census tract is used to determine environmental justice areas. Maps establish a stratification for the distribution: less than 10%, 10%-20%, 20%-25%, 25%-35%, 35%-50% and above 50%. The justification for the breakdown is not explicit (PSRC 2010b).

4.5.3 Equity and Accessibility

Puget Sound Regional Council treats equity as an entity independent, yet related to, environmental justice. It is positioned within the scope of sustainability, which is the guiding principle of *Vision 2040*. The prominence leads to increased incorporation into planning procedures and advanced methods of evaluation. An innovative procedure to evaluate access to opportunity is applied to the region to inform fair housing and equity of other development. The process is called Geography of Opportunity.

Through Geography of Opportunity, communities rich in opportunities such as housing, education, jobs, transportation and health are identified. The process of identifying opportunity-rich communities follows the Kirwan Institute's Opportunity Communities approach that was developed to "identify and remedy" discriminatory and unfair mechanisms in community development based on research in fair housing (Kirwan Institute for the Study of Race and Ethnicity 2007). The approach was applied to the Puget Sound region as a part of the Growing Transit Communities partnership. Based on a set of opportunity indicators, maps are generated showing areas of high and low opportunity. For PSRC, areas of high opportunity were identified by the presence of indicators found in Figure 29. The indicators were developed with the help of public participation. Data for each of the five indicators was used to calculate an opportunity index for each census tract (PSRC 2012).

Figure 29 Opportunity indicators used to produce opportunity indices for PSRC (PSRC 2012)

Maps for each of the five indicators and a composite map were created based on each tract's opportunity index. The opportunity maps were generated for the urbanized area of the region and compared to the distribution of race, nativity, disability, poverty, public assistance (including WIC and Section 8) and disadvantaged businesses. The data are aggregated for the region across population demographics to identify who has access to high- and low-opportunity communities (Figure 30). Housing becomes a primary focus for planning, however, access to light rail transit is also highlighted. The results of the opportunity mapping were incorporated into *Transportation 2040* and used to rank areas as high or low opportunity in the performance scorecard for Social Equity and Access to Opportunities.

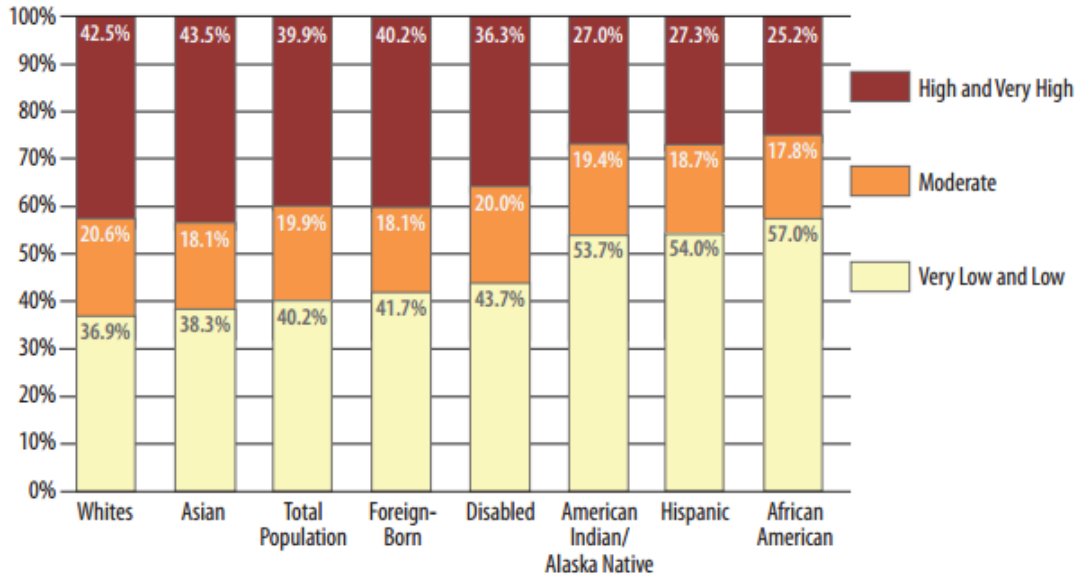


Figure 30 Opportunity distribution in PSRC by demography group (PSRC 2012)

PSRC evaluates equity separately from environmental justice and as such has the opportunity to innovate the analysis, which is done through Geography of Opportunity. Unlike the standard method, no target areas are delineated and access is evaluated across the entire population for each target population. Geography of Opportunity also innovates the measurement of accessibility moving it past travel time to destinations, incorporating housing, health and education concerns and providing an estimate closer to real accessibility rather than perceived accessibility. By using this innovative approach within a planning process that prioritizes equity, results in equity of access are used as a criterion for both project selection and program evaluation in a formalized, and even quantitative, way.

4.6 Boston Region MPO

4.6.1 Long-Range Planning Process

The Boston metropolitan region has a population of approximately 3.2 million residents in over 100 cities and towns across an area of nearly 1,500 square miles (Figure 31) (BRMPO 2011). The current long-range transportation plan, *Paths to a Sustainable Region*, guides regional transportation planning for a 20-year time horizon and was adopted in 2011. A series of amendments followed with the latest approved in 2013. On top of amendments, the long-range plan is updated every four years to keep pace with the changing region. The next update, *Charting Progress to 2040*, is currently being developed to be adopted in summer 2015. The new plan will provide a performance-based planning framework (Figure 32) to guide the future prioritization of programs and projects, set benchmarks, and track goals (BRMPO n.d.). The goals, along with the regional needs, land use, and potential projects, will be used to develop planning scenarios for the updated plan (Figure 33).

Figure 31 Boston Region Metropolitan Planning Organization planning area (BRMPO 2011)

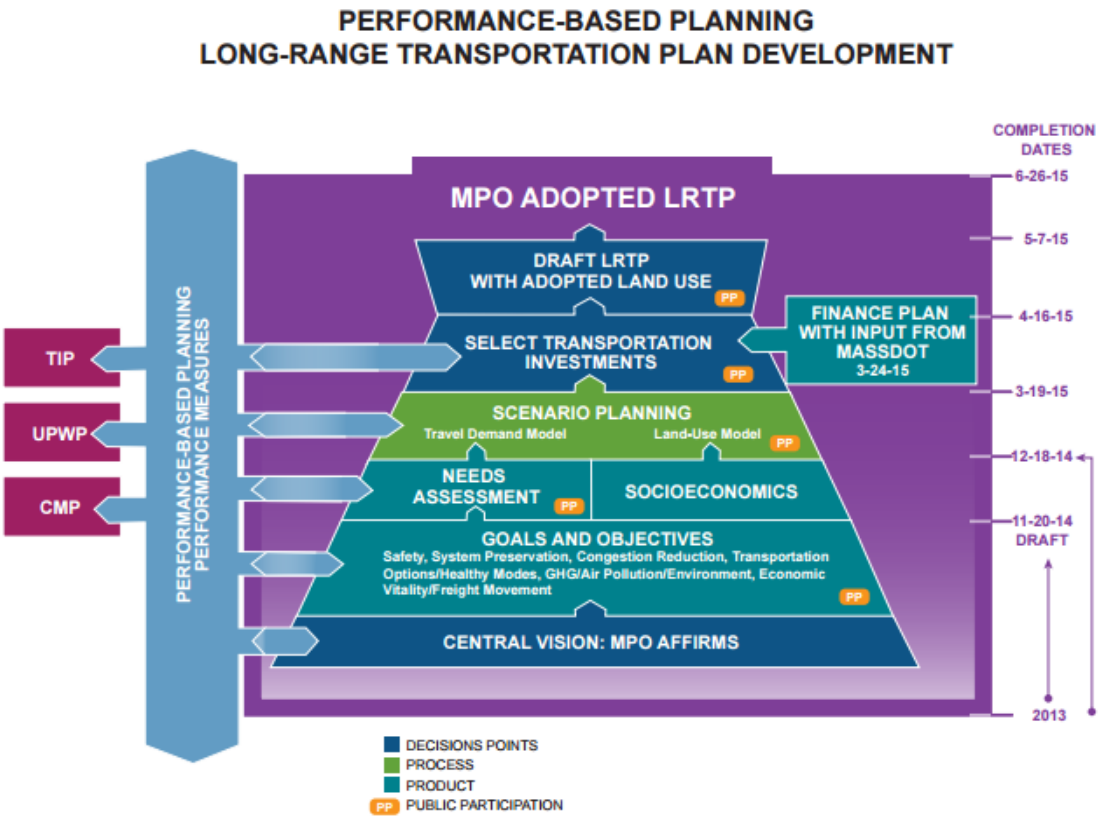


Figure 32 Performance-based planning framework for BRMPO long-range transportation plan development (BRMPO n.d.)

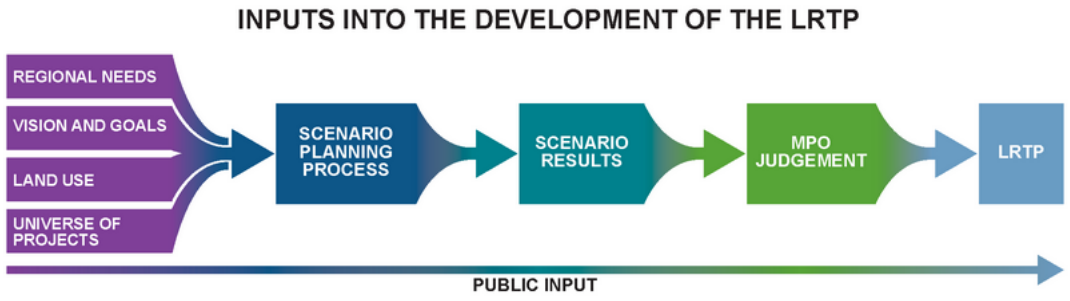


Figure 33 Planning process for the Boston MPO long-range plan "Charting Progress to 2040" (BRMPO n.d.)

The planning process for both *Charting Progress to 2040* and *Paths to a Sustainable Region* started with articulating a vision for the region and compiling a set of goals and policies that support this vision. For example, the vision for *Paths to a Sustainable Region* is to provide people of the region access to safe, healthy, efficient, and varied transportation option to jobs and services within easy reach of affordable

housing (BRMPO 2011). The vision for *Charting Progress to 2040* does not mention affordable housing but adds the use of new technologies, equitable access and excellent mobility to support a sustainable and livable region (BRMPO 2015a). The goals for the two long-range plans parallel each other with some variations. One goal that remains unchanged across the plans is "Transportation Equity," which refers to comparable mobility and access to jobs, education and services among communities regardless of income level or minority population (BRMPO 2011, BRMPO 2014). *Charting Progress to 2040* aligns three objectives with the goal of transportation equity: to remove barriers to participation in the decision-making process, to minimize burdens of MPO-funded projects to marginalized populations, and to target investments to areas that benefit marginalized populations. The objectives mirror the three fundamental environmental justice principles outlined by FHWA and FTA.

For the current long-range planning process as well as for *Charting Progress to 2040*, the regional needs assessment provides a comprehensive look at the state of the region and was used to identify regional priorities for the planning goals. Projects from the Universe of Projects are prioritized based in part on the projects' ability to advance the regional goals and address the regional needs. Transportation equity is highlighted as both a goal and a need for the region and is used as one criterion for project prioritization in the long-range plan and TIP along with the other planning goals that align with the vision and policies of the MPO – safety, system preservation, mobility, clean communities and economic vitality for *Charting Progress to 2040*. Additionally, projects are prioritized based on the recommended investment strategy scenario. Boston Region MPO created three investment strategy scenarios to address the planning goals and a recommended scenario was selected (BRMPO 2011, BRMPO 2014). Transportation equity is also assessed at the program level for a preferred investment scenario.

4.6.2 Equity and Accessibility

The new long-range plan, *Charting Progress to 2040*, analyzes the preferred scenario in three areas: Air Quality, Greenhouse Gas, and Transportation Equity (BRMPO n.d.). The evaluation of transportation equity follows steps similar to the environmental justice analysis. First Equity Analysis Zones are defined, which include TAZs with minority population greater than the regional average and median household incomes at or below 60 percent of the median income for the region (adopted from HUD). Boston Region MPO has also created demographic profiles for other target populations including limited English proficiency residents, the elderly and residents with disabilities but have not developed thresholds or target areas for these populations. The Equity Analysis Zones for minority and low-income populations are used both to target focused outreach efforts to identify transportation equity issues for the regional needs assessment and for the system-level transportation equity analysis of impacts. The transportation equity analysis determines the distributions of burdens and benefits – accessibility, mobility, congestion and air-quality – that result from the recommended investment scenario to target and non-target populations and compares the results to the future no-build scenario (BRMPO 2015b). The major infrastructure projects were modeled but specific projects were not included because they are selected through the TIP programming process. The TIP project selection also includes a separate environmental justice evaluation in the NEPA process. This process has not been completed, however, based on previous planning cycles it may follow a process similar to that of the equity analysis and consider the level of transportation investment within the Equity Analysis Zones (BRMPO 2015c, BRMPO 2011).

To evaluate accessibility, travel times via transit and highway to industrial, retail, and service employment opportunities, health care, and institutions of higher education were determined from all Equity Analysis Zones, examining minority and low-income populations separately. These travel times were compared to travel times for non-

minority and non-low-income populations for both the recommended build and the no-build future network. The analysis identifies the number of industrial, retail and service jobs accessible within a 40-minute transit trip and a 20-minute highway trip and the average travel time to these opportunities (Figure 34). The change in accessibility for the recommended build and no-build networks were compared for Equity Analysis Zones and non-Equity Analysis Zones. The ratio of this change was also compared to determine if both areas receive comparable benefits (Table 18) (BRMPO 2015b).

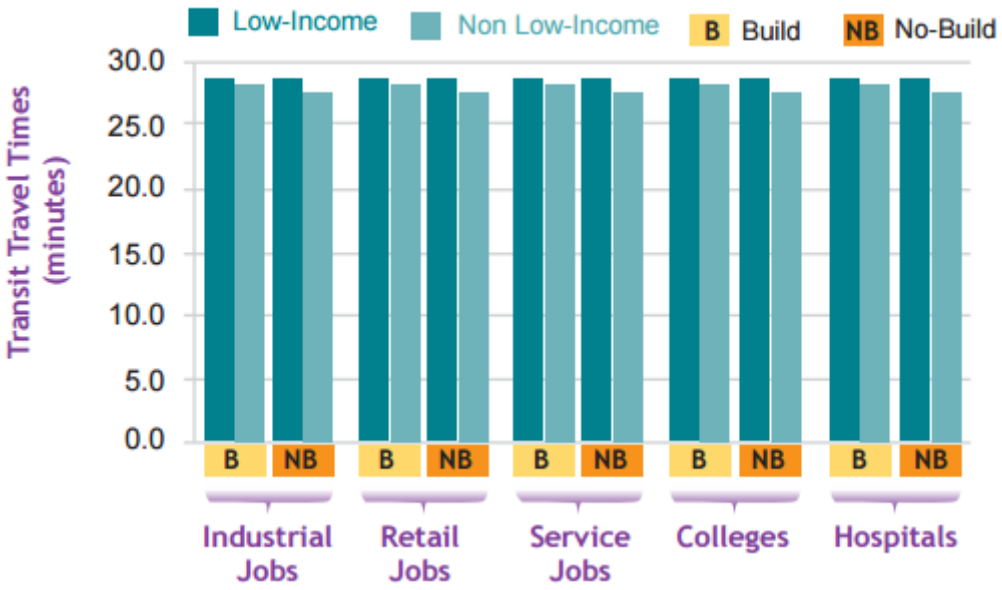


Figure 34 Average transit travel time to destinations for low-income and non-low-income Equity Analysis Zones in the 2040 no-build and 2040 build transportation networks (BRMPO 2015b)

Table 18: Comparison of Average Transit Travel Time to Employment Destinations (BRMPO 2015b)

	No-Build	Build	Pct. Travel-Time Increase	No-Build	Build	Pct. Travel-Time Increase	No-Build	Build	Pct. Travel-Time Increase[a]
	Industrial			Retail			Service		
Population									
Low-Income	28.7	28.7	0.0%	28.7	28.7	0.0%	28.7	28.7	0.0%
Non Low-Income	28.3	28.3	0.0%	28.3	28.3	0.0%	28.3	28.3	0.0%
Ratio	--	--	0.00	--	--	0.00			0.00
Burden Threshold	--	--	--	--	--				>1.20
Result: No Disproportionate Burden									
Population									
Minority	29.1	29.1	0.0%	29.1	29.1	0.0%	29.1	29.1	0.0%
Non-Minority	28.0	28.0	0.0%	28.0	28.0	0.0%	28.0	28.0	0.0%
Ratio	--	--	0.00	--	--	0.00	--		0.00
Burden Threshold	--	--	--	--	--	--			>1.20
Result: No Disparate Impact									

[a]All changes are within the model's margin of error.

As seen in Table 18, an impact is deemed disproportionate or inequitable if the difference in the level of impact between Equity Analysis Zones and non-minority or non-low-income areas is greater than 20 percent (burdened 1.2 times more or benefited 0.8 times less). Boston Region MPO states that a 10 percent differential is meaningful and included an extra 10 percent to account for the 10 percent margin of error in the travel demand model.

Boston Region MPO is a fairly standard example of equity evaluations, however, it provides an example of how MAP-21's performance-based approach is changing the long-range planning process. Of the cases reviewed, Boston is the first one being drafted after MAP-21 and as a result, not only are the national goals being incorporated into the update, but the MPO is adjusting its planning process to be more performance-based. As transportation equity remains a planning goal, there is an opportunity for Boston Region MPO to strengthen their equity evaluation as well as to incorporate equity considerations more formally into the planning process.

4.7 Conclusion

Four case study reviews were conducted to provide a view of what some of the best practices to incorporate equity principles in planning currently look like. The reviews surveyed the state of the practice, support the literature with pragmatic applications, and identified practices used in industry to be studied and tested in the analytical comparison of methods. This chapter discusses the long-range plan and the equity evaluation for each case study detailing the following for each MPO: the planning process, program development and in some cases project selection, how equity is used in program development, how accessibility is measured, and how the equity of access is evaluated. This information provides a practical basis for the research. The agencies' visions and goals and their program development process described the planning process for each organization and allowed for a better understand of how equity was or could be incorporated into the process to plan for equitable outcomes. The agencies' methods for evaluating equity showed how equity of access is being measured and highlighted limitations in the current practice. The results of the case study reviews showed similarities across MPOs, but for the most part, each case has a different procedure for using equity in program development, if it is used at all.

Four MPOs – Metropolitan Planning Commission, National Capital Transportation Planning Board, Puget Sound Regional Commission and the Boston Regional Metropolitan Planning Organization – were chosen as case studies because performance-based planning or equity evaluations that focused on accessibility were included in their long-range plans. One of the first questions asked to each MPO was if equity was included as a goal for the region. For both PSRC and MTC, equity is explicitly stated as a goal or objective for the region and is incorporated into the regional vision for sustainability. Although Boston Region MPO does not specify that equity is a goal or include it as a part of the vision, it does list equity among its top policies. Including equity as a goal in a performance-based planning process has potential to

influence decision making, particularly in a performance-based long-range planning process.

The PSRC and MTC planning processes reflect the strategic planning and performance management framework discussed in the literature review and shown in Figure 14. Both MPOs have a set of performance measures used to evaluate program scenarios' ability to meet regional goals. PSRC incorporates equity into the regional goals and vision and a number of the supporting policies encourage equity concerns (such as prevention or mitigation of negative effects towards low-income, minority and special needs populations, and expanding mobility choices for travelers with special needs such as the elderly). PSRC consequently used a set of performance measures to evaluate the ability of projects to meet regional goals and uses equity as one of the seven key criteria in prioritizing projects for the long-range plan. PSRC provides an example of project prioritization based on anticipated performance and potential equity benefits.

Equity is squarely situated in MTC's vision and its prominence can be seen through a set of equity performance measures that are used throughout the planning process to gauge performance towards the regional goal. MTC judges the performance based on whether or not performance targets are met, which is a key component of the performance management framework. Of the cases reviewed, MTC is the only MPO that sets performance targets for equity goals. Still, the adopted plan does not meet the equity target. There were other targets that were also not achieved, however the formal inclusion of equity in the decision making allowed it to be considered as trade-offs were discussed and helped to address shortcomings through other initiatives. Additionally, the set of equity measures used throughout the planning process reflects the prioritization of equity within the decision-making process.

TPB and Boston Region MPO do not have an established performance-based planning process. TPB uses performance measures such as accessibility in the evaluation of the program scenarios but it is not clear to what extent these results influence the

selection of the final program of projects. TPB alludes to the value of performance-based planning in their *Priorities Plan Assessment*. Boston Region MPO's plan update, scheduled to be completed in the summer of 2015, follows a performance-based framework and includes equity within the vision and the goals. One of the reasons for Boston MPO's shift to performance-based planning is necessitated by MAP-21. As long-range plans are updated over the next five years, MPOs will be required to implement performance-based planning frameworks to comply with this legislation. This insight is particularly relevant to ARC because they are in the process of updating their long-range plan.

The primary objective of the case study reviews was to understand how equity was assessed in practice; therefore, several questions were asked about the framework used for equity evaluation. The case study reviews revealed that equity evaluations are based on the need to meet federal requirements and typically follow the quantitative analysis for environmental justice outcomes process. Target populations are outlined, target areas are delineated, and impacts on those areas are compared to a reference population to determine disproportionality. TPB provides an example of the standard of evaluation method and Boston Region MPO also follows the process fairly closely. In general, each MPO follows the three steps to some degree.

As discussed in the Chapter 3, MPOs define target populations differently, always accounting for minority and low-income populations. MTC's decision to include target populations additional to minority and low-income populations provides insight for ARC. ARC modified their definition of target populations to focus only on minority and low-income populations by removing additional populations for the 2016 update of their long-range plan. Atlanta has discontinued using additional target populations due to redundancy of some populations and a lack of clustering for others. At the same time, the Atlanta region has seen an increase in minority population (ARC 2014c), which is the reason MTC began including additional populations. Similar to MTC, Boston Region

MPO has expanded their target populations past minority and low-income residents. Like ARC, however, they have found it difficult to determine a threshold that accurately delineates target areas for these populations. This complication further highlights the limitations of thresholds and target areas. It is worth noting that both PSRC and TPB include additional target populations and do not define target areas.

MTC and Boston Region MPO used their definition of target populations to delineate target areas that represent areas of high concentration for target populations. TPB and PSRC do not delineate target areas specifically for their equity evaluations. They develop demographic profiles for the region that are based on thresholds for reference but they assess the impacts on the total population of specific demographic groups and compare the distribution of impact across demographic groups. One limitation that was highlighted by Boston Region MPO (Mcgahan 2015) but is shared by the other case studies that use forecasted comparisons in the equity evaluation is the assumption that target populations will remain unchanged.

All the cases were chosen in particular because they evaluated equity in regards to regional accessibility. Accessibility is often the telltale benefit used in equity evaluations at the regional level. Only four case studies were selected for further study, however, of the 12 original cases identified 8 included measures of accessibility within their equity evaluations. This reflects the significance of accessibility and the understanding that it is a prime benefit or good derived from the transportation network.

Accessibility measures differed between MPOs. Each MPO with the exception of PSRC measured accessibility as a function of travel time to destinations. The travel times were taken from travel demand modeling output. TPB assumed accessibility is the number of jobs within 45 minutes. Boston Region MPO considered accessibility to be the number of a variety of destinations within a set travel time based on mode. Both of these measures are essentially a cumulative opportunity measure. PSRC based accessibility on a set of indicators to determine the level of opportunity. The focus here

is more heavily weighted on the level of opportunity and not the ability to travel to the opportunity, emphasizing the land use component of accessibility measures. MTC considered accessibility the average travel time for work and non-work trips based on the results of an activity-based travel demand model.

How accessibility was compared for disproportionality is also subject to the MPO. MTC compares the forecasted travel time results for the target areas across the programming scenarios. They also determine the change in travel time between the base year and the preferred scenario and compare it between the target areas and the remainder of the region. TPB similarly compares changes between the current base year model and the forecasted year, but compares the changes across all populations, noting percentages of each population with minimal, moderate, and significant change. PSRC and Boston Region MPO do not compare forecasted impacts to a base year but focus on comparing the projected impacts across populations. Boston Region MPO is similar to MTC and compares the accessibility between the target areas and the rest of the region where PSRC is similar to TPB and compares accessibility across all demographic groups, evaluating the percent of each population within areas of high, moderate, and low access to opportunities.

The driving force for equity in most MPOs is environmental justice regulations. Expanding equity evaluations past this can benefit long term equity but it is necessary to meet federal requirements. The MPOs that expand their equity evaluation (MTC and PSRC) conduct separate environmental justice analysis to meet requirements. Evaluations either lend to focusing on demographics or on spatial location of high concentrations of target populations. TPB commented that federal requirements do not lend to creativity in the process and that because they have limited authority and are limited in their abilities to innovate.

The variety of planning approaches and evaluation methods was used to inform the analytical comparison of methods and the recommendations for incorporating equity

considerations into long-range planning at metropolitan planning organizations. Table 19 concludes the chapter by comparing the values of Equitable Transportation Planning with the findings of the case studies.

Table 19: Summary of Case Studies and Equitable Transportation Planning

Value for Equitable Transportation Outcomes	Discussion	Metropolitan Transportation Commission	National Capital Transportation Planning Board	Puget Sound Regional Council	Boston Region MPO
Continues to address environmental justice regulations and concerns	The driving force for equity analysis in most MPOs is environmental justice regulations. Expanding equity evaluations past this can benefit long term equity but it is necessary to meet federal requirements. The MPOs that expand their equity evaluation (MTC and PSRC) conduct separate environmental justice analysis to meet requirements.				
Expands the concept of equity to apply regionally across various populations	Evaluations either lend to focusing spatially on locations of high concentrations of target populations or generally on regional demographic information. A streamlined process that looks both spatially and demographically is not practiced but MPOs show evaluation in both areas. This research proposes using distributions of demographics but spatial representations are important for political and practical reasons.			Equity evaluation has spatial and demographic components	
Works at a level to plan for the comprehensive transportation network	The cases apply equity considerations at the regional level, not just for project-level analysis. There are examples of project-level evaluation but all cases have a process for examining equity at the program-level for the comprehensive transportation network. Equity considerations are included in program scenario selection (MTC and PSRC) or program scenario analysis (BRMPO) but not all MPOs practice scenario planning (TPB).				
Incorporates performance in equity (improvements and regressions) in future planning	Cases evaluate equity within the specific planning cycle and do not compare across planning cycles. MTC has begun the process with Snapshot Analysis. TPB and ARC use the travel demand to explain current impacts and BRMPO conducts a formal needs assessments based on current state. PSRC uses the current state as the basis for its evaluation. In cases where there is temporal comparison, changes between the base year and a forecasted scenario are evaluated.	Snapshot Analysis			
Considers equity as one of multiple planning priorities	Two MPOs (MTC and PSRC) have sustainability as a vision (that includes equity). Both of these MPOs have made efforts to measure and assess equity among other prioritized measures.				

Value for Equitable Transportation Outcomes	Discussion	Metropolitan Transportation Commission	National Capital Transportation Planning Board	Puget Sound Regional Council	Boston Region MPO
Does not suggest a new planning process, works within a metropolitan transportation planning process that currently incorporates performance management	Performance-based planning is established in two of the cases (MTC and PSRC) and is being implemented in a third (BRMPO). ARC is also moving towards more performance-based planning measures.				New plan is performance-based

Legend
Incorporates the value
Has some consideration for the value
Does not address the value

CHAPTER 5

LONG-RANGE PLANNING AND EQUITY FOR THE ATLANTA REGIONAL COMMISSION

5.1 Introduction

This chapter presents the findings from an examination of the Atlanta Regional Commission's (ARC) long-range planning process. In a format similar to that of the case studies in Chapter 4, this chapter details that comprehensive and transportation planning, project prioritization, equity procedures and measurement of accessibility for the Atlanta area metropolitan planning organization (MPO). The information is heavily based on the current plan, PLAN 2040, but includes information on changes that are pending as the new plan is being drafted. The information is distilled from documents published by the organization as well as staff interviews. Finally, it assesses Atlanta practices using the values of planning for equitable transportation outcomes.

5.2 Atlanta Regional Commission

The Atlanta Regional Commission serves 4.8 million people and spans 18 counties, approximately 4,600 square miles (Figure 35). The current long-range comprehensive plan, PLAN 2040, was originally adopted in 2011 and most recently updated in early 2014. A purpose, values, objectives and principles are used to organize the plan. The purpose and a set of three values were based on regional issues and opportunities gleaned from input from stakeholders and the 50-year visioning effort, "Fifty Forward." Also as a result of the visioning effort, sustainability was identified as a theme to underscore PLAN 2040. Sustainability is defined using the triple bottom line (Figure 36). This theme is clearly visible in the purpose which is, "visionary leadership for sustainable growth by balancing environmental responsibility, economic growth and social needs while maximizing benefits to all." Each of the five objectives (Figure 36) are supported by a set of principles, which together to form the official land use policy for the region and guides programming and investment decisions within the Implementation Strategy (ARC 2011a). The ARC works with state agencies, quasi-governmental

organizations and non-profit groups in implementation. The ARC Implementation Plan and the Regional Implementation Partners document identify activities that will be undertaken in the next five years and serve as the implementation framework for the long-range plan.

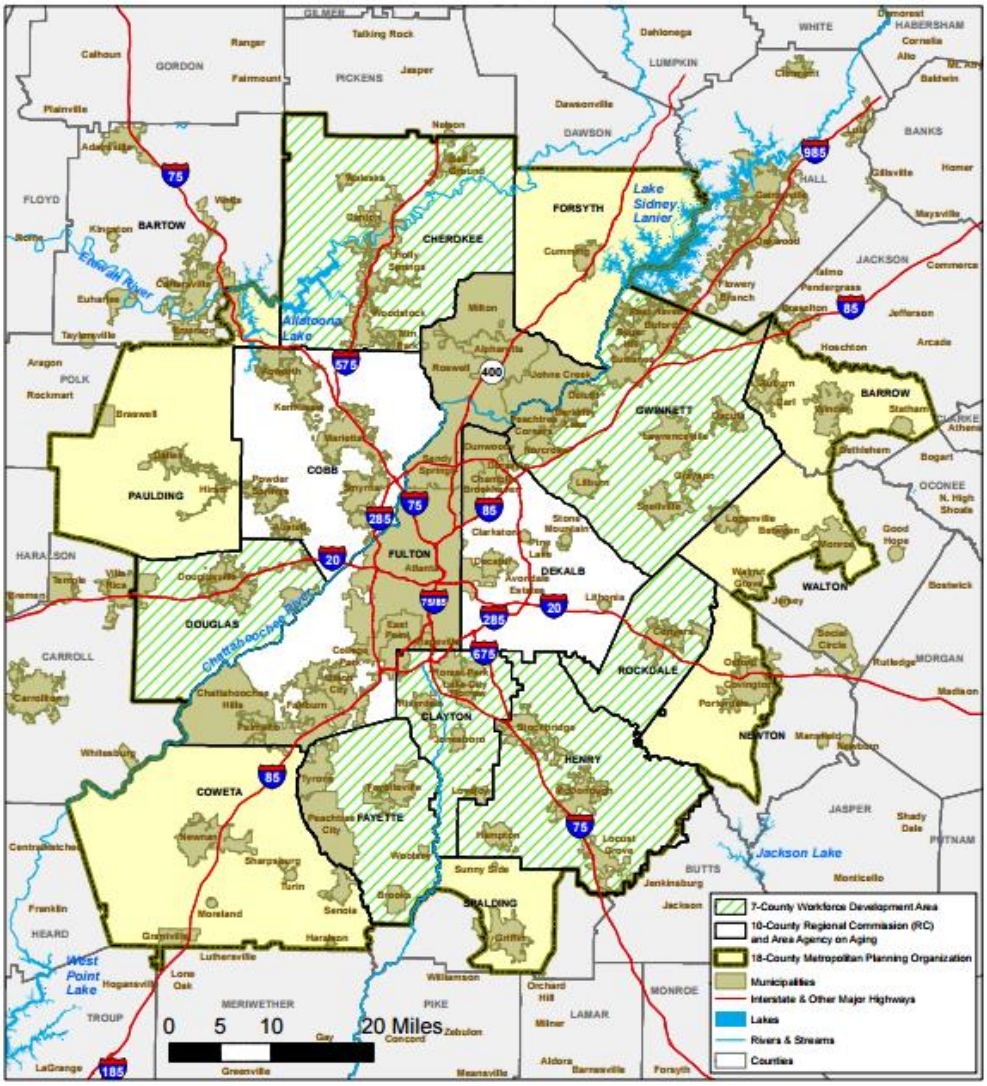


Figure 35 ARC planning region. The 18-county area is in yellow and outlined in with dash-dot line. (ARC 2012)

Figure 36 ARC's PLAN 2040 vision and objectives

Equity is not explicitly discussed (outside of embracing diversity of the regional community and housing options) in the objectives or principles, however accessibility is reflected in the objective to "Promote places to live with easy access to jobs and services." The values also establish the goal of expanding access to community resources, which includes providing reliable transportation alternatives especially to regional centers (ARC 2014a). Despite the absence of equity in the objectives, ARC was active in the arena of procedural equity while developing PLAN 2040 and had a Community Engagement Plan, Social Equity Advisory Committee, focus groups and listening sessions (ARC n.d.). Furthermore, environmental justice assessments for the planning scenarios were conducted through an Equitable Target Area Analysis discussed later in this chapter.

5.3 The ARC Planning Process

PLAN 2040 is composed of two elements, the Regional Agenda and the Regional Transportation Plan. The Regional Transportation Plan (RTP) is a component of PLAN 2040 that details plans for the future of transportation based on the needs and land use plans identified in Regional Agenda (ARC 2014a). The 2014 update built upon the plan adopted in 2011 with some adjustments, including a revised decision-making framework for transportation project evaluation. The plan was initially designed around four key decision points that guided a process for categorizing, filtering and ranking projects. As shown in Figure 37, projects were first separated into the appropriate category based on the type of project. Any projects that were not consistent with regional policies outlined in the Regional Agenda were eliminated. At the third decision point, the remaining projects were input in a travel demand model and the output was

analyzed based on performance in the areas of Mobility, Connectivity, Safety, Economic growth, and Environment/Community Impact. Projects that could not be modeled were evaluated by extra measures. The technical results were compared to the project costs to calculate the benefit-cost ratios for each project. Comparison of the projects benefit-cost ratios provided informational support for Key Decision Point 4. Figure 38 shows this process in more detail.

Figure 37 Decision-making framework for project evaluation in *PLAN 2040* (ARC 2011b)

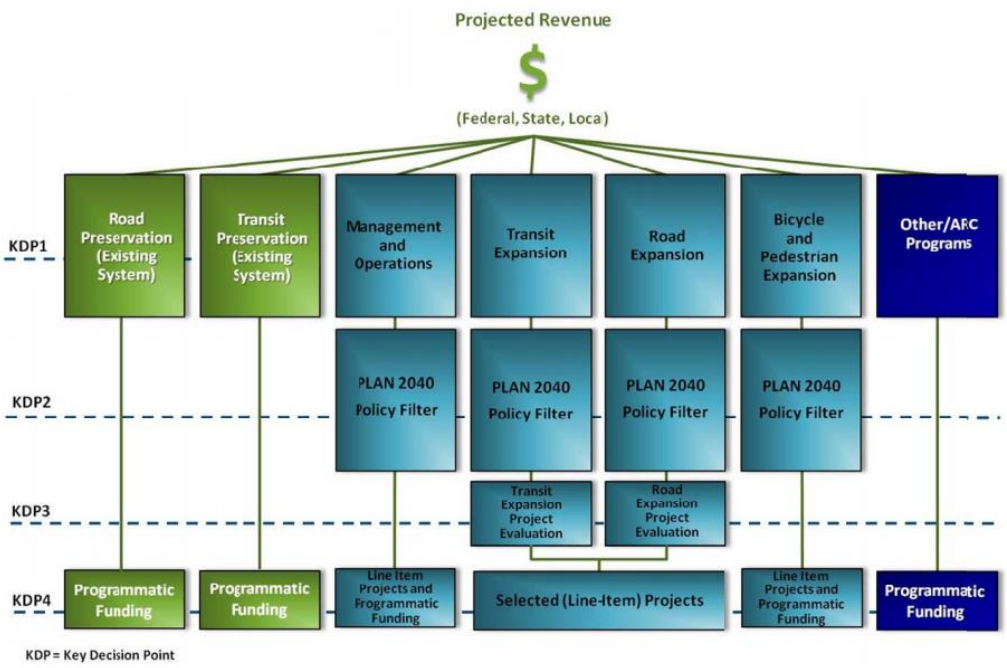


Figure 38 Regional transportation plan performance framework (ARC 2014d)

The new Decision-Making Framework primarily affects Key Decision Point 3 and the technical evaluation of road and transit expansion projects. It measures performance and provides system-wide measures that are consistent with MAP-21 and the State Strategic

Transportation Plan (SSTP) (Table 20) to guide prioritization in the RTP. The measures in Table 21 were used to evaluate plan-level performance in the update. There was a heightened emphasis on safety and the safety evaluation was done using new data; however, other measures remained unchanged from the last plan update.

Table 20: Measuring Performance at Federal and State Levels

MAP-21 National Performance Goals	SSTP Performance Metrics
1. Safety	1. Average number of workers reaching major employment centers by car or transit in 45 minutes
2. Infrastructure Condition	2. Annual congestion cost
3. Congestion Reduction	3. Average commute time
4. System Reliability	4. Number of people taking reliable trips per day
5. Freight Movement and Economic Vitality	5. Number of traffic fatalities
6. Environmental Sustainability	6. Peak-hour freeway VMT
7. Reduced Project Delivery Delays	7. Peak-hour freeway speed

Table 21: Plan Level Performance Measures for PLAN 2040 March 2014 RTP Update and Results (ARC 2014a)

Performance Emphasis Area	Measure Description	2015 Base		2040 No-Build		2040 Constrained	
Mobility	Average commute travel time by auto / transit (in minutes)	Walk to Transit	58	Walk to Transit	60	Walk to Transit	60
		Drive to Transit	59	Drive to Transit	79	Drive to Transit	77
		Automobile	39	Automobile	61	Automobile	53
Connections / Accessibility	Worker access to employment centers within 45 minutes by car (index)	1.0		0.57		0.77	
	Worker access to employment centers within 45 minutes by transit (index)	1.0		0.87		1.10	
	Average number of jobs within 45 minutes of home for typical person	472,677		308,360		400,015	
Economic Growth	Total congestion cost per person	$1,862		$5,023		$3,900	
	Number of reliable trips in PM peak period	89,065		132,518		215,406	
	Peak period highway VMT	17,377,388		22,146,969		22,044,383	
	Peak period highway speed (mph):	General Lanes : 41 Managed Lanes: 48		General Lanes : 29 Managed Lanes: 41		General Lanes : 32 Managed Lanes: 44	
	Peak Period truck delay (hours)	101,722		419,156		323,544	
Safety	Percent of all regional crashes with an identified PLAN 2040 Update project	-		-		24 %	
	Percent of PLAN 2040 Update projects that intersect above average crash rate facilities	-		-		100 %	

The ranking process in Key Decision Point 3 was used to prioritize projects rather than to select them. Project proposals are initially submitted by counties, cities, transit agencies or other entities seeking federal transportation funding of at least $1 million (ARC 2014e). There is typically a selection process by these entities before they are submitted and all projects are accepted by ARC. The projects are then subject to the objective project prioritization process. Some are recommended for funding and included in the TIP. A second set is included in an unconstrained list of projects. The projects were ranked into four tiers and scored from 1 to 100, and the top projects were prioritized for funding. The list of projects remained the same between updates despite the change in decision-making framework, but the prioritization of the list was revamped based on the framework (Roell 2015).

The new framework compares the performance results to the results of the Regional Needs Assessment. It shifts focus to the current needs and uses historical travel data to support decisions as opposed to relying on forecasted data from the travel demand model. The analysis is done at a project level, primarily using GIS and data from sources in Table 22. Benefit-cost ratios and air quality were also used in project evaluation. The process for measuring accessibility is based on travel demand model results still, but the output is based on a current network and not a forecasted one. The accessibility measure used determines which roads carry the highest percent of trips to and from the regional activity centers. The number of trips to and from each regional activity center during the PM peak on each roadway link was compared to the total number of trips on that roadway link. This represents the percent of trips each link carries to and from any of the regional activity centers and allows projects to be prioritized based on the access they provide.

Table 22: Project Level Performance Measures for PLAN 2040 March 2013 RTP Update (ARC 2014d)

Performance Area	Dedicated Performance Measure/Metric	Data Source
Congestion/Mobility	**Weighted Maximum Travel Time Index** (ratio of congested travel time over free-flow travel time)	2010 HERE Geographical and Traffic Data
Safety	**Injury and Fatality Crash Rate** (injury and fatality crashes per 100 million vehicle miles traveled)	2009 GEARS (Georgia Electronic Accident Reporting System) Data and the ARC 2010 Regional Travel Demand Model Output
Employment Accessibility	**Accessibility Ratio** (percent of all vehicle trips that originate or are destined to one or more UGPM major activity centers)	ARC 2010 Regional Travel Demand Model Output
Travel Demand	**Average 2010 Weekday Traffic Volume**	ARC 2010 Regional Travel Demand Model Output

As suggested by Table 21 and Table 22, analysis was done at both the regional-level and at the project-level; the regional analysis informed the project-level analysis. For the mobility performance measure, however, applying travel demand results at the project level produced unrealistic results and a Three-Tiered Modeling approach (Figure 39) was piloted to refine the results. The regional model provided data that is used as meso-level inputs. The results of the mesoscopic analysis (Figure 40) were then used to evaluate a small set of individual projects. This was an experimental process and it was discovered that it was resource intensive. Particularly, there were problems identifying the links that should be included at the microscopic level. It was not used in the updated prioritization process.

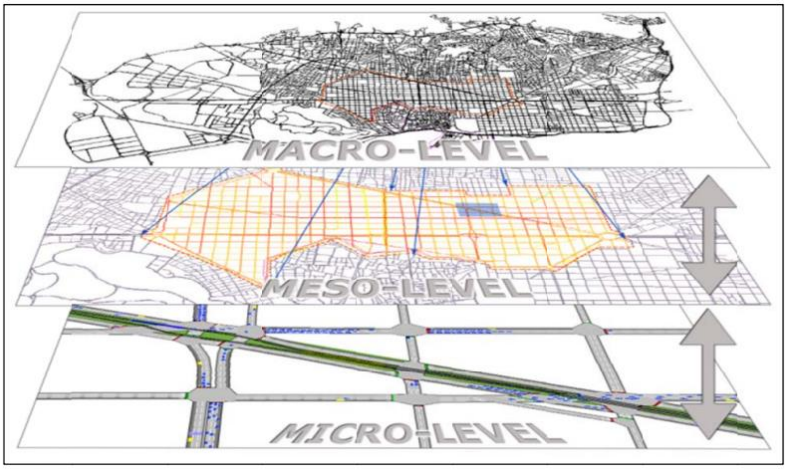


Figure 39 Three-tiered modeling concept (ARC 2014d)

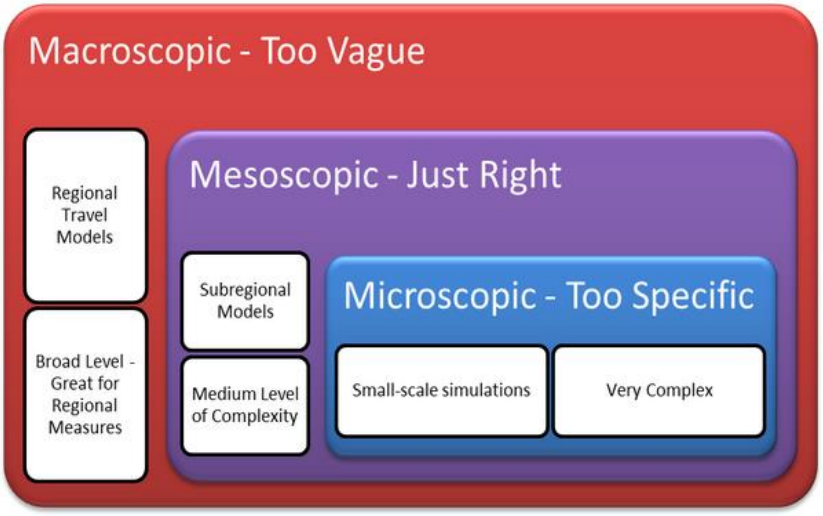


Figure 40 Mesoscopic modeling framework (ARC 2011b)

Once projects are prioritized into the financially constrained program of the RTP, the plan is evaluated at the program level. Impacts of the program of projects are derived from the travel demand model. The process compared a future build and future no-build scenario against a base scenario across a set of measures. Table 21 shows the performance measures that were used to compare the current base year performance to a forecasted build and no-build alternative (ARC 2014a). These measures also incorporate MAP-21 National Performance Goals as well as state performance metrics from the SSTP.

Accessibility at the program level evaluated access to employment by automobile, transit and walking. For auto and transit accessibility, PM peak travel time to the regional employment centers was determined based on the base year, 2040 build and 2040 no-build options. Walking accessibility was evaluated based on potential demand. This was measured by the intersection grid and the number of households, services and retail jobs to which a person could walk. A multimodal accessibility measure was also created that provided a composite understanding of access to employment by all three modes within a 45-minute transit trip, a 30-minute drive or a 15-minute walk (ARC 2014a).

The decision-making framework was developed for the 2014 update and was intended to provide a foundation for the current planning cycle (ARC 2013). The ARC is currently in the process of developing the next long-range regional plan, which has an anticipated completion of spring 2016. At this stage, the Commission has completed early stage stakeholder involvement and has published both the regional assessment and the transportation assessment (ARC 2014b). Most recently, ARC has also published a working draft of the goals and objectives that are guiding the plan (ARC 2015b). The framework sets goals for a competitive economy, healthy livable communities and world class infrastructure with supporting objectives, one of which is to promote an accessible and equitable transportation system. The Transportation Assessment examines the region in light of these goals (ARC 2015a). Findings specific to equity and accessibility are discussed in Chapter 6.

5.4 Equity at ARC

The Atlanta Regional Commission bases its definition of equity on several definitions, including that of PolicyLink ("just and fair inclusion where all can participate and prosper") and the Victoria Transportation Policy Institute ("the equitable distribution of impacts"). Social equity issues are often addressed through an environmental justice lens) (ARC 2014f). ARC has been developing their equity evaluation (centered on environmental justice) over the last fifteen years. In 1999, ARC established the Environmental Justice Planning Team to advise and guide the agency's long-range planning for transportation, land use, housing, economic development and other relevant issues as they relate to the effects of projects and policies on underrepresented populations. The Team became called the Social Equity Advisory Committee and comprised members of community organizations, educational institutions, environmental organizations, local and state government and the ARC Board (ARC 2014g). The committee's first active engagement was in the Mobility 2030 planning process and it subsequently conducted extensive outreach efforts and implemented technical assessment processes to evaluate transportation needs for minority and low-income populations in the Atlanta region (ARC 2006). The Social Equity Advisory Committee was also involved in the PLAN 2040 process. A workshop was organized by ARC and held in early 2010 to share the initiatives of PLAN 2040 and receive input from advocacy groups. The Social Equity Advisory Committee then served as the liaison to social equity communities. Meetings of the committee continued quarterly. In the current plan development process, the Poverty, Equity, Opportunity Committee is guiding a series of workshops on "Building Opportunity" that are geared towards policy suggestions and feedback from civic and non-profit leaders, locally elected officials, community members and universities (ARC 2014b).

The ARC evaluates equity within the context of environmental justice. It follows a process that identifies Equitable Target Areas (ETA) and assesses impacts for these areas of the region. As early as the late 1990s, ARC defined environmental justice areas as any census block group that contained a target (African-American, Hispanic, Asian or low-income) population percentage greater than the regional average for the target population. In 2007, the Commission hired a consultant to explore concerns that some areas defined as environmental justice areas were not necessarily experiencing a disadvantaged quality of life. The resulting study used a

Community Attribute Index (CAI) to evaluate a number of weighted variables along five dimensions. The CAI was developed based on the United Nations Development Program's Human Development Index that is used to evaluate nations and local indices such as the Community Vitality Index and the Neighborhood Quality of Life Index. Figure 7 is the framework for the CAI (Boston and Boston 2007).

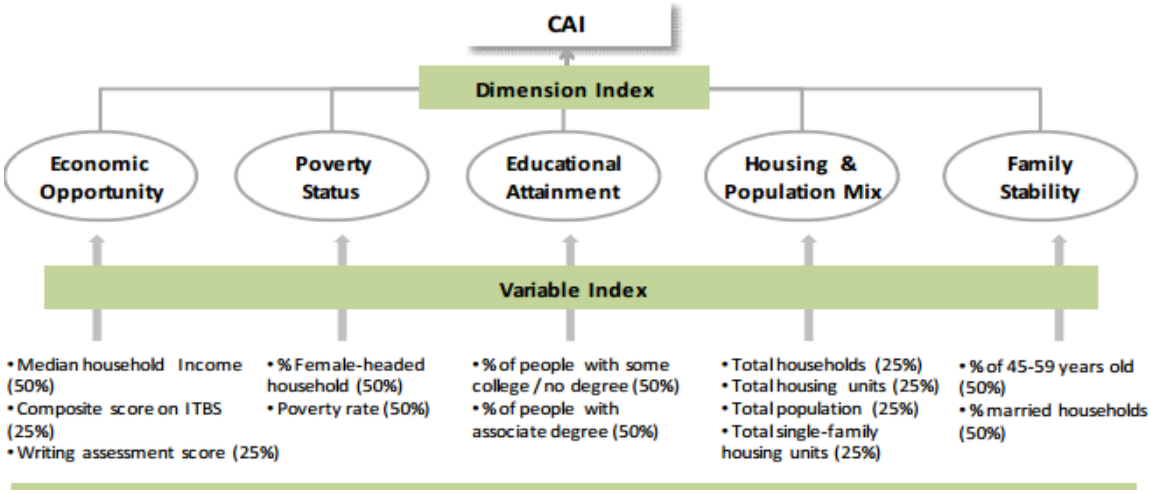


Figure 41 Atlanta Regional Commission Community Attribute Index Framework (Boston and Boston 2007)

One goal of the study was to move beyond race and poverty and include other factors that are influential to the level of advantage one might experience. The consultants' report states, "The important point is not that race and poverty should be abandoned as criteria, but they should be supplemented with other metrics… (Boston and Boston 2007)" With this understanding, ARC developed the Equitable Target Area Analysis in 2011 for PLAN 2040. This index used five demographic parameters to identify disadvantaged areas: age, education, median housing value, poverty and race. Similar to past assessments, census tracts with target populations over the regional average are identified. They were then scored for each parameter (Boston and Boston 2007). The scores were combined to determine the total index for each census tracts across the region. Areas with high scores were defined as ETAs. This process was updated in 2014 for the plan update and a similar process is being used for the new plan (ARC 2015a). The ETAs are used as input for project prioritization and at the program level they are used to monitor resource allocation to target populations (Roell 2015). ETAs are also being integrated into other decision-making processes at ARC and may be used in the evaluation of program scenarios (Roell 2015).

The 2015 ETAs are defined based on poverty and race solely again. Original concerns about disadvantaged quality of life are addressed by using high concentrations of poverty as a limiting factor in determining ETAs. ARC identified a correlation between poverty and education and housing, but also found that these did not necessarily relate to poor jobs or poor quality of life and only served to double count poverty as a variable; therefore, these target populations were removed from the list of ETAs. Additionally, there were no substantial areas with a high population over age 65, and this variable was eliminated from the analysis so that it would not dilute the results. To develop the ETAs, the concentration of households in poverty, and the African-American, Asian, Hispanic, and other non-white race populations for each census tract were determined. The standard deviations for each of these demographic segments (excluding the outliers) were used to create categories. A census tract was considered Category 1 if its percentage exceeded the highest standard deviation, Category 2 if it was between the highest and second highest standard deviation and Category 3 if it was below the second highest standard deviation. ETAs were defined as any tract that fell into Category 1 or 2 for poverty. Minority population categories were then used in distinguishing between "very high" and "high" in the ETA Index. "Very high" ETAs are tracts with both poverty and minority populations in Category 1. A "high" ETA index reflects tracts with poverty in Category 1 but minority populations in Category 2 or lower. Finally, "medium" level ETAs are tracts with poverty in Category 2, regardless of minority population. Figure 42 shows the current ETAs being used for the plan update.

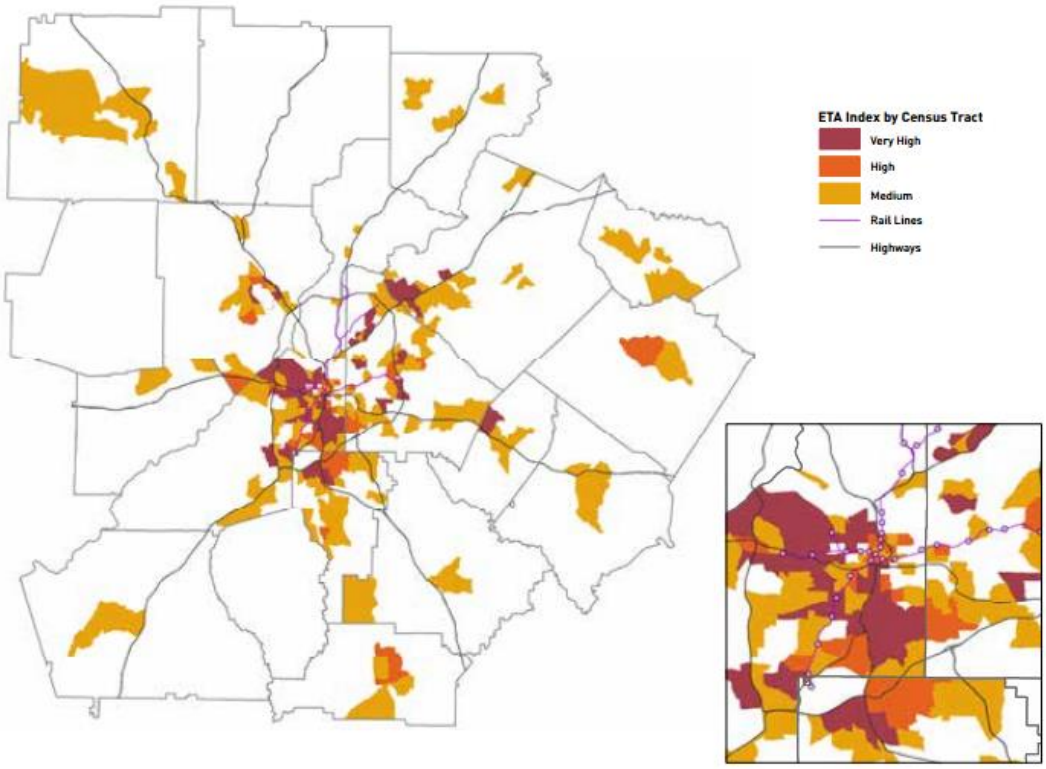


Figure 42 ARC Equitable Target Areas for 2016 Plan Update (ARC 2015a)

The ETAs were historically used to identify if projects were planned in areas heavily populated with marginalized populations by comparing what percentage of the projects were planned relative to the percentage of the regional population that resided in the ETA. Travel demand model results were also used to evaluate the changes in impacts for ETAs. A new process is being used in the updated plan. Using OpenTripPlanner transit data, accessibility in ETAs can be determined and similar to the other performance measures, the outcomes are based on the current state and not the forecasted model. This information supported the Transportation Assessment. Using OpenTripPlanner and ladders of opportunity, the definition of accessibility is moving from travel time to work to a more opportunities-based measure of accessibility. The ladders of opportunities identify hospitals, libraries, colleges, public and private schools within a 60 minute transit trip, and grocery stores within a 30 minute transit trip.**Error! Bookmark not defined.** Also, as mentioned previously, ARC is incorporating ETAs into other decision-making processes such as project evaluation analyses and in-depth neighborhood studies led by committees of the organization.

5.5 ARC and Planning for Equitable Transportation Outcomes

Based on the findings of this case study and validation of the findings by ARC, the planning process and equity evaluation can be examined from the lens of the Equitable Transportation Planning values for equitable transportation outcomes in a similar manner as the case studies in Chapter 4. Table 23 summarizes these findings.

Table 23: Comparison of ARC and Values for Equitable Transportation Planning

Value for Equitable Transportation Outcomes	Summary of Case Studies (see Chapter 4)	Atlanta Regional Commission
Continues to address environmental justice regulations and concerns	The driving force for equity in most MPOs is environmental justice regulations. Expanding equity evaluations past this can benefit long-term equity but it is still necessary to meet federal requirements. The MPOs that expand their equity evaluation (MTC and PSRC) conduct separate environmental justice analysis to meet requirements.	Equity is viewed in the context of environmental justice and the environmental justice analysis is used as an evaluation of equity.
Expands the concept of equity to apply regionally across various populations	Evaluations either lend to focusing spatially on locations of high concentrations of target populations or generally on regional demographic information. A streamlined process that looks both spatially and demographically is not practiced but MPOs show evaluation in both areas. This research proposes using distributions of demographics but spatial representations are useful for political and practical reasons.	There is a focus on representing target populations geographically and a high importance is placed on using ETAs for equity concerns.
Works at a level to plan for the comprehensive transportation network	Equity may be used for project-level evaluation but it is also applied to evaluate the program of projects. There are examples of project-level evaluation in the cases but they all have a process for examining equity at the program-level for the comprehensive transportation network. Equity considerations are included in program scenario selection (MTC and PSRC) or program scenario analysis (BRMPO) but not all MPOs practice scenario planning (TPB).	Past processes have not used equity in program-level decision-making but equity has been analyzed for the regional network. The draft planning process may use equity in evaluating program scenarios.
Incorporates performance in equity (improvements and regressions) in future planning	Equity is typically evaluated within the specific planning cycle and not compared across planning cycles. MTC has begun to compare historical trends with Snapshot Analysis. TPB uses the travel demand to explain current impacts and BRMPO conducts a formal needs assessment based on current state. PSRC uses the current state as the basis for its evaluation. In cases where there is temporal comparison, changes between the base year and a forecasted scenario are evaluated.	The travel demand model is used to explain current impacts but collected transit data is also used for the plan update assessment. Still, any temporal comparison uses forecasted data from the travel demand model.

Value for Equitable Transportation Outcomes	Summary of Case Studies (see Chapter 4)	Atlanta Regional Commission
Considers equity as one of multiple planning priorities	Equity is a planning goal of two MPOs (MTC and PSRC), both of which include equity within their vision of sustainability. Both of these MPOs have also made efforts to measure and assess equity among other prioritized measures.	Equity is not an explicit goal in PLAN 2040 but promoting an equitable transportation system is an objective of the plan update. Specific decision-making criteria related to equity have not yet been established.
Does not suggest a new planning process, works within a metropolitan transportation planning process that currently incorporates performance management	Performance-based planning is established in two of the cases (MTC and PSRC) and is being implemented in a third (BRMPO).	There is progress towards more performance-based planning measures, especially as the plan is updated with respect to MAP-21 performance-based planning requirements.

Legend
Incorporates the value
Has some consideration for the value
Does not address the value

CHAPTER 6

FINDINGS AND ANALYSIS

6.1 Introduction

This research was motivated by gaps in transportation planning and decision making towards achieving equitable outcomes of the transportation system over time. To address these gaps, two questions are answered by the quantitative analysis of this chapter:

- How does one develop a demographic profile within a practical spatial unit of analysis to inform transportation program development?
- How can one identify the level of equity of an impact across a region?

The research was designed to compare approaches used in practice and the literature to a proposed method in order to assess the impact of transportation improvements on regional accessibility and evaluate the processes through the lens of Equitable Transportation Planning values.

As explained in Chapter 2, standard practice conducts quantitative analysis of environmental justice outcomes in three steps as shown in Figure 43. There are several limitations to this method including the limited scope of equity resulting from the focus on specific target populations, the use of target areas, the use of average impacts, the dependence on reference populations, and the inability to capture cumulative impacts. This chapter applies a proposed method for equity evaluation that adjusts the standard practice to address these limitations (Figure 44). This approach does not reconstruct the standard process but reframes it to analyze the distribution of an impact, provide flexibility in demographic analysis and support contextual analysis of impacts over time.

Figure 43 Standard practice for quantitative analysis of environmental justice outcomes

Figure 44 Proposed process for equity evaluation of cumulative impacts

The research design, explained in Chapter 3, establishes three components of the quantitative research that are used in both the standard practice and the proposed method. The three components – the demographic analysis, impact assessment and the equity evaluation – comprise the foundation for the analytical comparison of methods presented in this chapter. The chapter is organized corresponding to these three components, first exploring the current state of practice and applying its process to the case study of Atlanta and then applying the proposed methods to the same case study. The findings from this chapter will be used to support the development of procedures for formally considering equity in the long-range planning process.

The first section of this chapter, Demographic Analysis, addresses the research question: How does one develop a demographic profile within a practical spatial unit of analysis to inform program development? It applies the current state of practice analysis using thresholds to delineate areas of high concentrations of target populations and highlights limitations through statistical and spatial analysis. It then provides an alternative demographic analysis method. The second section is the Impact Assessment, which outlines how the Atlanta Regional Commission (ARC) measures accessibility and presents the results from the impact assessment conducted for this research. The final section, Equity Evaluation, synthesizes the results of the previous two sections to draw conclusions about equitable outcomes in order to address the question: How can one identify the level of equity of an impact across a region?

This chapter tests and applies industry practices to provide quantitative illustrations of gaps and limitations of current practices and presents an alternative method that addresses the gaps and limitations by producing information that can be incorporated into a performance-based planning framework to achieve equitable outcomes for the transportation system.

6.2 Demographic Analysis

The first step in the environmental justice quantitative analysis is to identify target populations. The MPO case study review (Chapter 4) highlighted the various target populations that are considered in different metropolitan areas. Even among the populations that are federally required and therefore accounted for by each MPO (minority and low-income populations), there are differences in how these populations are defined, namely in how low-income is defined. For this research, low-income was defined as families with incomes below 80% area median income (AMI), using median family income data from the US Census Bureau. This measure was used to combat limitations of the HHS poverty threshold and provide a geographically sensitive guideline. Setting income limits using a percentage of AMI is practiced by the Department of Housing and Urban Development, the European Union and also one of the case studies, Boston Region MPO (HUD 2015, European Commission 2013, BRMPO 2015c). By this measure, target areas were defined as any census tract where the percentage of families with incomes below 80% AMI was greater than the regional average for these families (due to data limitations family income under $60K, or 83%, was used as the threshold). The manner in which target populations are defined determines which residents are included in the demographic analysis; therefore, it has implications for the final equity evaluation because it determines what populations are analyzed. Table 24 summarizes the various target populations that are considered in the case study MPOs. Each MPO accounts for minority and low-income populations as mandated, along with a number of other marginalized populations. The target populations shown for ARC reflect those considered in PLAN 2040. The draft of the pending update only considers minority and low-income populations.

Table 24: Target Populations for Select MPOs

MPO/DOT	TARGET POPULATIONS											
	Minority	Low-Income	LEP*	Disabled	Elderly	Zero-Car	Single-/Female HOH	Education	Cost Burdened	Foreign-Born	Youth	Housing Values
Atlanta Regional Commission	x	x			x			x				x
Metropolitan Transportation Commission	x	x	x	x	x	x	x		x			
National Capital Regional Transportation Planning Board	x	x	x	x	x							
Puget Sound Regional Council	x	x		x						x		
Boston Region MPO	x	x	x		x						x	
Southern California Association of Governments	x	x		x								
Southeast Michigan COG	x	x			x	x						
Mid-Ohio Regional Planning Commission	x	x		x	x	x						
San Diego Association of Governments	x	x										
Houston-Galveston Area Council	x	x			x	x		x				
Delaware Valley Regional Planning Commission	x	x	x	x	x	x	x					
Maricopa Association of Governments	x	x	x	x								
Central Lane MPO	x	x	x	x	x	x						

*Limited English Proficiency

Differences in the methods used to develop demographic profiles further influence the final equity evaluation because the methods also govern which residents will be included in the analysis. The most common method used in environmental justice analyses to develop a demographic profile is to delineate "target areas" of census tracts via thresholds. This research hypothesizes that different thresholds will create different demographic profiles within target areas and will lead to substantial differences in equity evaluations. Additionally, the literature asserts that thresholds fail to capture significant portions of target populations. This will also be tested. Four thresholds were applied to the ARC planning area of 18 counties to delineate target areas for African-American, Hispanic and low-income populations. The sensitivity of using the regional average, plus-standard deviation, plus-25 and 50 percent thresholds (as explained in Chapter 3) is tested using statistical analysis and GIS spatial analysis.

6.2.1 Statistical Analysis of Standard Practice

In the Atlanta metropolitan region, the African-American population makes up 33.4% of the population. This is used as the regional average threshold. A large percent of the African-American population (74%) live in census tracts that surpass the regional average threshold (Table 25). This suggests that the African-American population is heavily concentrated. The other three thresholds are higher percentages and therefore correspond to stricter limits. Applying them delineates fewer tracts as target areas and captures a smaller portion of the population. The plus-25 percent threshold is fixed relative to the regional average and works to provide a more stringent filter. This additional rigidity, however, has little to do with the total target population and more to do with the concentration of the target population within a given census tract. Therefore, applying more stringent thresholds does not necessarily focus attention on more residents within a target population but on areas with a high concentration of target population. Because the African-American population is heavily concentrated, the threshold methods capture at least half of the target population (Table 25). For less concentrated populations, as is shown in the Hispanic and low-income populations, a smaller portion of the target population is represented by the target areas. The thresholds for low-income population capture a lower percentage of the target population despite having more tracts within target areas than the African-American or Hispanic populations. This may be because there are relatively more low-income families than minority individuals (exhibited by the higher regional average). The differences between the thresholds will be examined further, but one point is made clear on initial analysis: target areas are affected differently depending on the population and which threshold is applied. The size and concentration of the population influence the target area that is delineated by thresholds.

Table 25 shows the results of the sensitivity test for African Americans, Hispanics and low-income families in the Atlanta metropolitan area. The table compares the number of tracts, total population and target population contained within target areas defined using four different threshold methods. The thresholds are also compared in relation to the percentage of the regional population and the regional target population that is contained within target areas.

Table 25: Comparison of Population in Target Areas based on Threshold

African-American Population

	Regional Threshold	Number of Tracts	Total Population	Target Population		Regional Population	Percent of Regional Population	Regional Target Population	Percent of Regional Target Population
Thresholds		**in Target Areas**					**in Target Areas**		**in Target Areas**
Regional Average	33.4%	348	1,849,010	1,219,915		4,970,225	37%	1,659,297	74%
Plus-25%	41.8%	293	1,511,966	1,093,479		4,970,225	30%	1,659,297	66%
Plus-Standard Deviation	65.6%	184	904,873	776,638		4,970,225	18%	1,659,297	47%
50% of unit	50.0%	241	1,231,549	965,035		4,970,225	25%	1,659,297	58%

Hispanic Population

	Regional Threshold	Number of tracts	Total Population	Target Population		Regional Population	Percent of Regional Population	Regional Target Population	Percent of Regional Target Population
Thresholds		**in Target Areas**					**in Target Areas**		**in Target Areas**
Regional Average	10.8%	238	1,385,492	351,954		4,970,225	28%	536,332	66%
Plus-25%	13.5%	190	1,076,356	315,083		4,970,225	22%	536,332	59%
Plus-Standard Deviation	23.4%	106	572,865	224,787		4,970,225	12%	536,332	42%
50% of unit	50.0%	24	123,449	75,644		4,970,225	2%	536,332	14%

Low-Income Families

	Regional Threshold	Number of tracts	Total Families	Target Families		Regional Population	Percent of Regional Population	Regional Target Population	Percent of Regional Target Population
Thresholds		**in Target Areas**					**in Target Areas**		**in Target Areas**
Regional Average	44.3%	445	545,763	343,170		1,223,424	45%	542,191	63%
Plus-25%	55.4%	317	355,055	247,399		1,223,424	29%	542,191	46%
Plus-Standard Deviation	69.2%	167	159,473	125,902		1,223,424	13%	542,191	23%
50% of unit	50.0%	388	460,743	303,072		1,223,424	38%	542,191	56%

The thresholds themselves are not related to the distribution of the population; they are based on a point of central tendency for the regional population, either the average or 50 percent. The plus-standard deviation threshold is relative to a distribution but not the distribution of the population. The plus-standard deviation threshold is based on the distribution of census tracts and their concentration of target populations. Theoretically, plus-standard deviation increases the threshold to a point greater than 84% of the population, a point that highlights approximately 16% of tracts with the highest concentration of a given target population. In this case however, the distributions are not normal and this threshold does not produce an intuitive limit.

The 50 percent threshold is an example of a fixed threshold. This is not based on the regional population or its distribution; it is an arbitrary point. Because of the high concentration of African-Americans in the region, 58% of that target population is accounted for within the target area defined by this threshold. In contrast, when the 50 percent threshold is used to identify target areas for the less concentrated Hispanic population, it captures only 14% of the population.

The Hispanic population composes 11% of the Atlanta metropolitan region population. Analyzing Hispanic populations showed that they are also concentrated within certain census tracts; however, the degree of this concentration is less than African-American populations and these tracts are more dispersed throughout the region. Although Hispanic populations are less centrally located, there is focal point in Gwinnett County. This is a point of common knowledge and is also shown in spatial analysis (Figure 46). Of the 238 tracts that surpass the regional average, 73 are in Gwinnett County and account for approximately 40% of the Hispanic population in the target area defined by the regional average threshold.

Using the 50% threshold for low-income populations captures over half of the target populations; however this is not necessarily because of high concentrations but because of a relatively high regional average (44%) and a large number of tracts with low-income populations above the regional average (445). Although there is no distinct concentration of tracts for low-income populations, approximately two-thirds of the tracts are in the southern portion of the region (Figure 47).

The results shown in Table 25 support the assertion that different thresholds will define substantially different target areas and produce different demographic profiles. The percentage of the target population accounted for within target areas varies depending on the threshold chosen. The regional average threshold captures the largest percentage of each target population. Because the plus-25 percent threshold is based on the regional average, the percentage of the population captured corresponds to that delineated by the regional average threshold; less tracts and fewer residents of target populations are represented. The plus-standard deviation threshold also corresponds to the regional average but it has a stricter threshold than plus-25 percent so it represents still less of the target population in the target areas. How much the target population varies between thresholds is different, which supports the hypothesis that thresholds are sensitive to the demographic segment.

This sensitivity is further evidenced with the 50 percent threshold. The 50 percent threshold captures a much higher percentage of African-American and low-income populations than Hispanic populations because of the differences in concentration of the populations within tracts and the size of the populations. This has implications for defining numeric thresholds for use across all populations and suggests that caution be used when applying a numeric threshold

for use across multiple population segments. The finding also highlights the complications produced due to varying concentration of populations.

The tables show that significant portions of the target population (86% at worst, 26% at best, based on the threshold and population) can be left out of the target areas and therefore the equity evaluation, reinforcing concern that significant portions of target populations may be neglected in equity evaluations that use target areas based on thresholds to define target populations. Environmental justice regulations require the evaluation of impacts on the whole target population, not just on areas of high concentration, in this way, thresholds excluding 86% of the population are ineffective for environmental justice analysis. Even those neglecting 26% are not fully compliant with the federal guidance. As agencies begin to use more stringent thresholds to adjust for increasing minority populations or concerns for disadvantaged quality of life (such as MTC and ARC respectively), this finding becomes more salient.

Although many MPOs use the regional average to delineate thresholds, the demographic context may influence the thresholds that the MPO chooses. MTC has a large and continually growing minority population and has established a more stringent threshold to delineate the target area. The stricter limit was established to prevent large portions of the region from falling into target areas in order to focus attention more directly on target populations (Johnson 2015). ARC also uses a stricter threshold for similar concerns; there is a high minority population and focus should be placed on those with a reduced quality of life (Roell 2015).

This research asserts that it is beneficial, and necessary, to explore effects on the entire region. Focusing on areas in the region with high concentrations of a target population does not support a level of precision for informed decisions on program development to achieve equitable outcomes for the regional population (i.e. to achieve an equitable transportation system). This research does not apply all the various ways MPOs have developed demographic profiles; however, it does highlight some of the results that can using a standard process from practice.

One point that is clear from this analysis is that the thresholds create a "cut-off" point to define what will or will not be considered a target area. The nature of thresholds, and target areas in general, create a situation where some portion of the target population will be excluded from the profile and, as such, from the subsequent equity evaluation. Additionally, target areas based on thresholds do not correspond directly to the population in the region or the distribution of this population. Instead, the thresholds are related to the concentration of the target population

within the tracts, neglecting the magnitude of the population within them. In all, demographic profiles based on thresholds are sensitive to the threshold chosen, the population analyzed and the population's distribution. The spatial distribution and concentrations and the size of target populations are factors in the portion of the target population that is captured by each threshold. Because these characteristics change between demographic groups, thresholds will delineate target areas differently for various target populations. For each target population, the target areas resulting from each threshold are shown in Figure 45, Figure 46, and Figure 47. These figures also show the results of the spatial analysis that is discussed in the succeeding chapter.

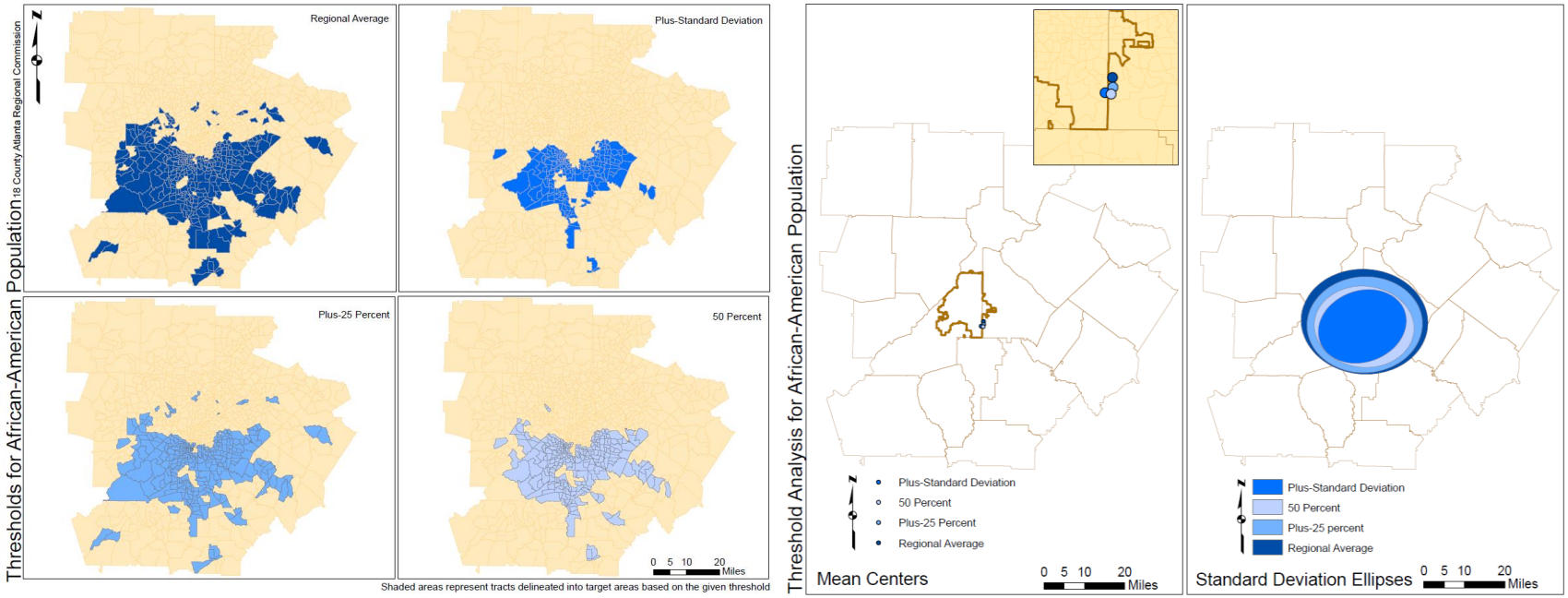


Figure 45 Threshold analysis for African-American population in the 18-county ARC planning region

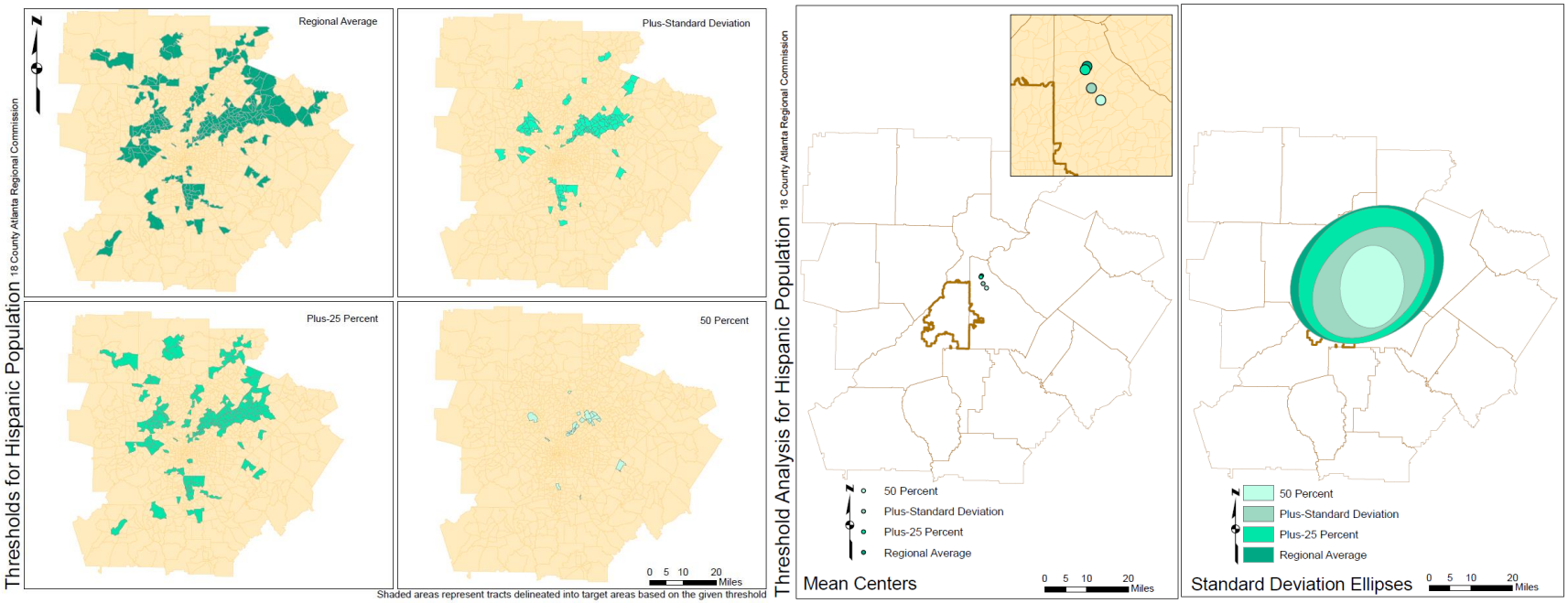


Figure 46 Threshold analysis for Hispanic population in the 18-county ARC planning region

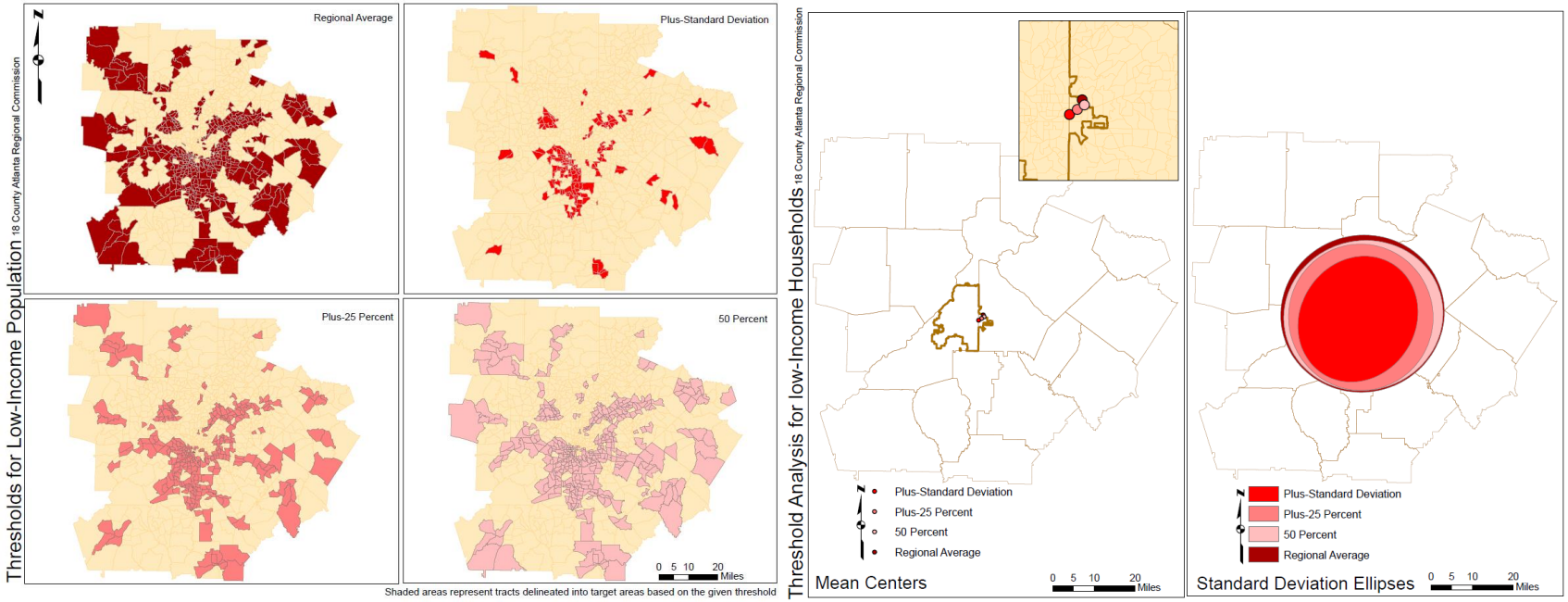


Figure 47 Threshold analysis for low-income population in the 18-county ARC planning region

6.2.2 GIS Spatial Analysis of Standard Practice

Analyzing the thresholds spatially provides additional information. Spatially, the African-American target areas are in the southern half of the region. This is a point of common knowledge for the region and holds true for all four thresholds. It is also shown in the mean centers and standard deviation ellipses of the tracts within the target areas (Figure 45). The visual representation in Figure 45 echoes the statistical analysis in Table 25; both show how the number of tracts decreases as the thresholds change. For the African-American population, it also shows that the location of the tracts throughout the region become more concentrated spatially.

The Hispanic target areas are less spatially concentrated as seen in Figure 46. The mean centers are north of the city of Atlanta in Gwinnett County graphically explaining the concentration of Hispanic populations in Gwinnett. Figure 46 shows that as the thresholds change fewer tracts are contained in the target areas. This difference is more drastic for Hispanic populations than African-American.

The target areas for low-income families are distributed across the region for each of the four thresholds. Again the number of tracts in the target area varies based on the threshold but there is no defined concentration of tracts. In fact, the mean centers and standard deviation ellipses are focused at the center of the region, expressing a fairly even distribution for the target areas across the region.

A common practice in delineating target areas is to aggregate all target populations. The result is a regional target area that represents all target populations. This can be accomplished in various ways including overlaying target areas for all segments and including either all tracts or only those tracts that are common. This research also tested the effects of aggregating target populations into one target area. Three target areas were delineated, one using ARC's current methodology and two based on the regional average thresholds. The latter two overlaid the regional average thresholds for minority (African-American and Hispanic combined) and low-income populations. One combined target area used the intersection of the two populations to identify all tracts that met the regional average threshold for both target populations. The other used union of the target areas to identify all tracts that met the regional average

threshold for either target population. In most cases, however, when the target areas are combined a tract meeting either criterion will be included. Figure 48 shows the combined target areas based on the regional average threshold. The difference between the maps is whether target areas must meet the threshold for both populations. This can be addressed by creating tiers and identifying areas as high or very high with regards to target populations. ARC adopts this method.

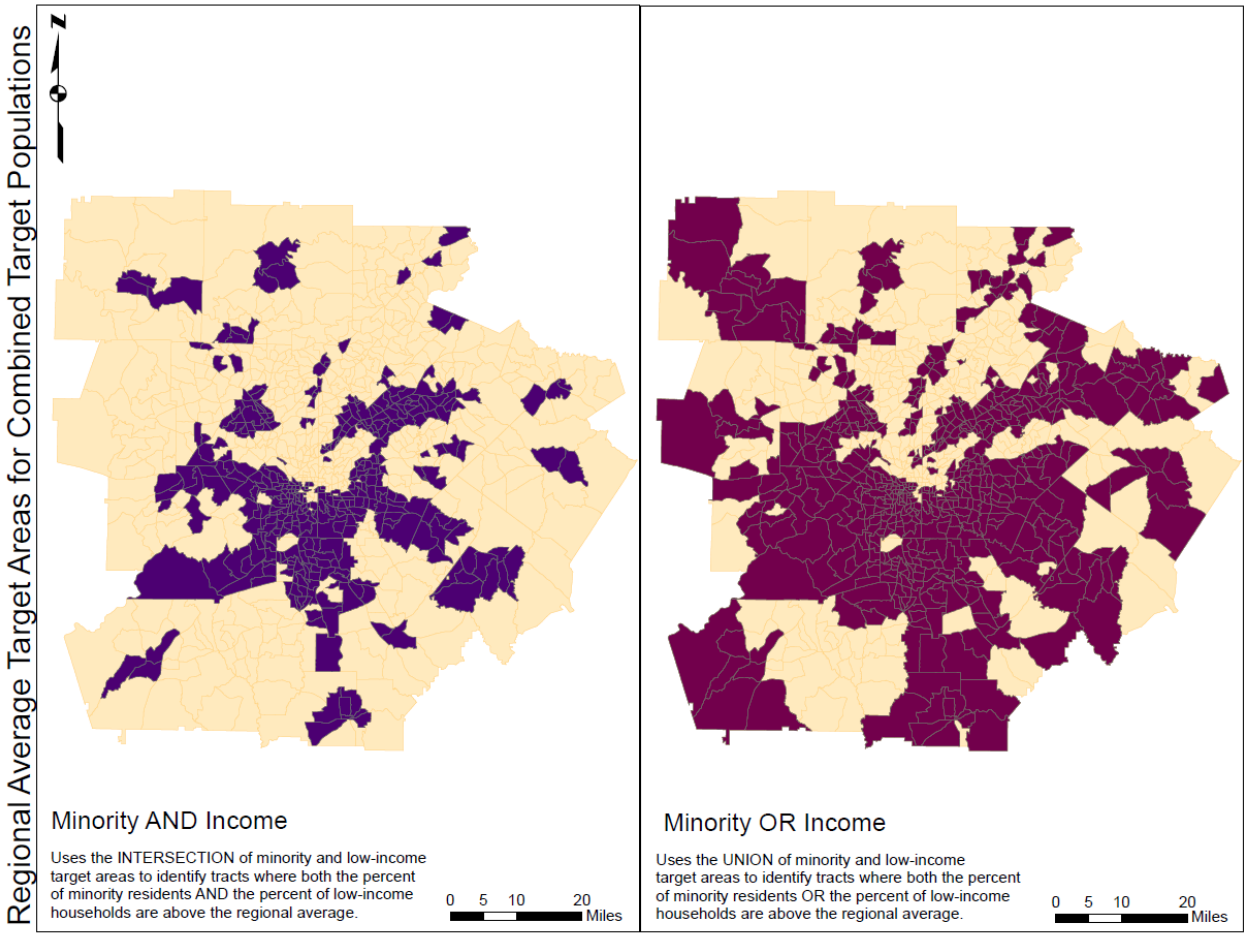


Figure 48 Target areas by combining target populations for minority and low-income populations. Target areas are defined using regional average thresholds.

ARC's methodology uses a threshold similar to the plus-standard deviation threshold and a full explanation of their process is provided in Chapter 5. Figure 49 shows the target areas, referred to as Equitable Target Areas (ETA), that are defined for minority and low-income populations in the Atlanta region. There are areas reflecting

very high, high and medium levels of target populations based on which populations met the threshold. Table 26 breaks down the demographic makeup of combined target areas for the regional average thresholds and the ETAs. When the target populations are grouped together to create target areas, more of the target populations are included (when all tracts identified as target are included) however, because different populations may have different concerns, precision is lost. This is even more applicable when populations such as zero-car households or elderly populations are included in the equity evaluation because these populations typically have different needs.

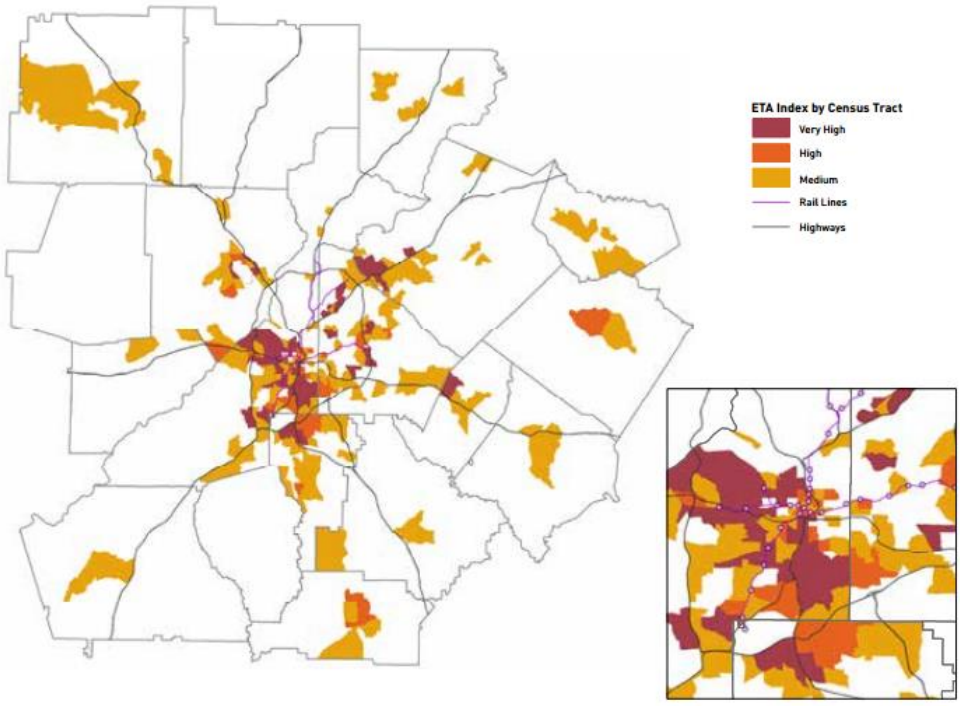


Figure 49 ARC Equitable Target Areas for 2016 Plan Update (ARC 2015a)

Table 26: Demographic Composition of Combined Target Areas

Combined Threshold	Number of Tracts	Total Population	African-American Population	Hispanic Population	Low-Income Families
	in Target Areas				
Minority AND Low-Income	381	1,984,361	1,073,791	334,422	291,879
Minority OR Low-Income	566	3,135,528	1,448,052	435,979	412,850
Equitable Target Area	236	1,100,130	595,885	204,506	167,078

6.2.3 Proposed Method for Demographic Profiles

Concentrations of target populations are informative. This research recognizes the importance of areas with high concentrations of specific demographic segments. However, by applying the procedure commonly used in practice to develop demographic profiles based on thresholds, the different results that are produced by each type of thresholds, as well as their effect on different populations, is elucidated. It has been shown here and suggested in other research (Hartell 2007, Karner and Niemeier 2013) that thresholds have serious limitations for equity evaluations. This research asserts and has shown that thresholds have some critical sensitivities and areas of high concentration do not fully represent the target populations. Therefore, it proposes a different approach that does not delineate target areas.

To address the limitations of the environmental justice quantitative analysis procedure, including the limitations related to thresholds, it becomes necessary to modify the current method used for most equity evaluations. This research proposes an evaluation process that does not develop a demographic profile of the region first and instead examines effects on demographic segments after impacts have been assessed. In this way, the process is able to produce a demographic profile based on impacts that affect the total target population. This method accounts for a more holistic view of the target populations to overcome the methodological limitations of standard demographic analysis. Demographic profiles based on distributions of impacts are applied in the following section on equity evaluation. However, Figure 50 depicts the spatial distribution of minority and low-income populations. These profiles highlight areas of high target populations regardless of the concentrations and showcase the full spatial distribution of the target populations showing that target populations reside in non-negligible numbers within tracts that are excluded in the target areas.

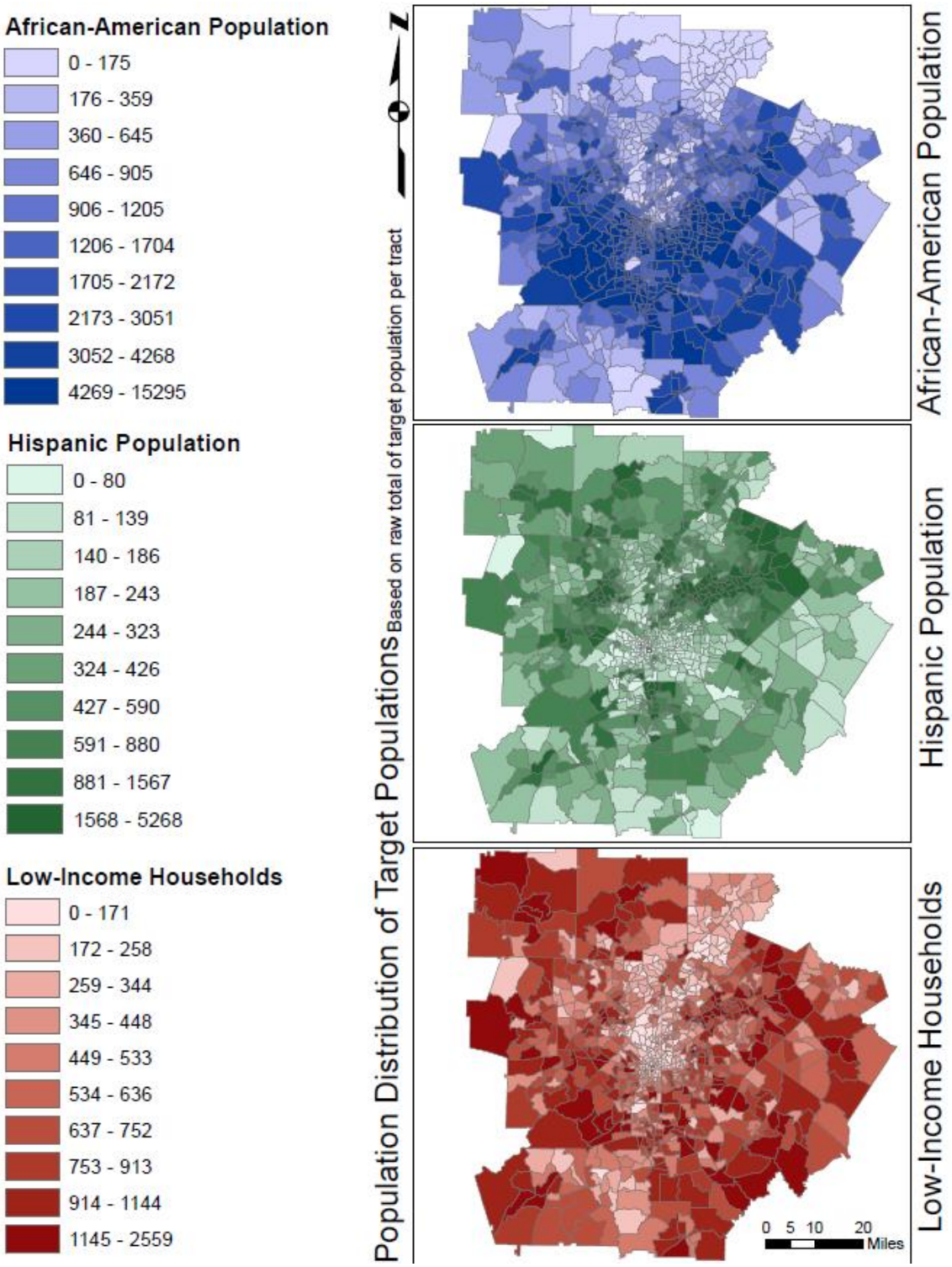


Figure 50 Regional distribution of target populations based on raw total in each tract

This research asserts that a comprehensive demographic profile that explores the spatial distributions of the regional population and various demographic segments of

interest, namely target populations, can assist in efforts to better understand the needs of the residents of the region and inform the development of the program of projects towards achieving equitable outcomes. A comprehensive demographic profile provides the opportunity to evaluate impacts on additional residents outside of the target populations as defined in regulation and also addresses the limitation of neglecting portions of the target population. It provides the opportunity to understand impacts and effects of transportation improvements on the region independent of demographic segment and has the potential to evaluate impacts on the entire population. This method will address limitations of the current methods for developing demographic profiles.

The first limitation of the current methods is the focus on concentrations, which as discussed in Chapter 3, does not fully meet the USDOT standard for identifying target populations since thresholds cannot adequately capture populations that are not concentrated in geographic proximity. It is necessary therefore, to use an analysis based on the actual target population. The proposed method uses the entire regional target population to understand the impacts for that target population. The mean centers of the thresholds are compared to the mean centers of the regional population for each target population in Figure 51 to show how the spatial distribution of the regional population differs from a measure based on concentration of target populations. For African-American populations, when the focus is on the whole population and not areas with high concentrations, the spatial distribution of the target population is represented differently. This suggests that although tracts with high concentrations of African-American residents may have a focal point, the total African-American population of the region is more dispersed. The difference in mean centers is less clear for Hispanic and low-income populations, which may be because highly concentrated tracts are distributed throughout the region, unlike African-American tracts that congregate geographically.

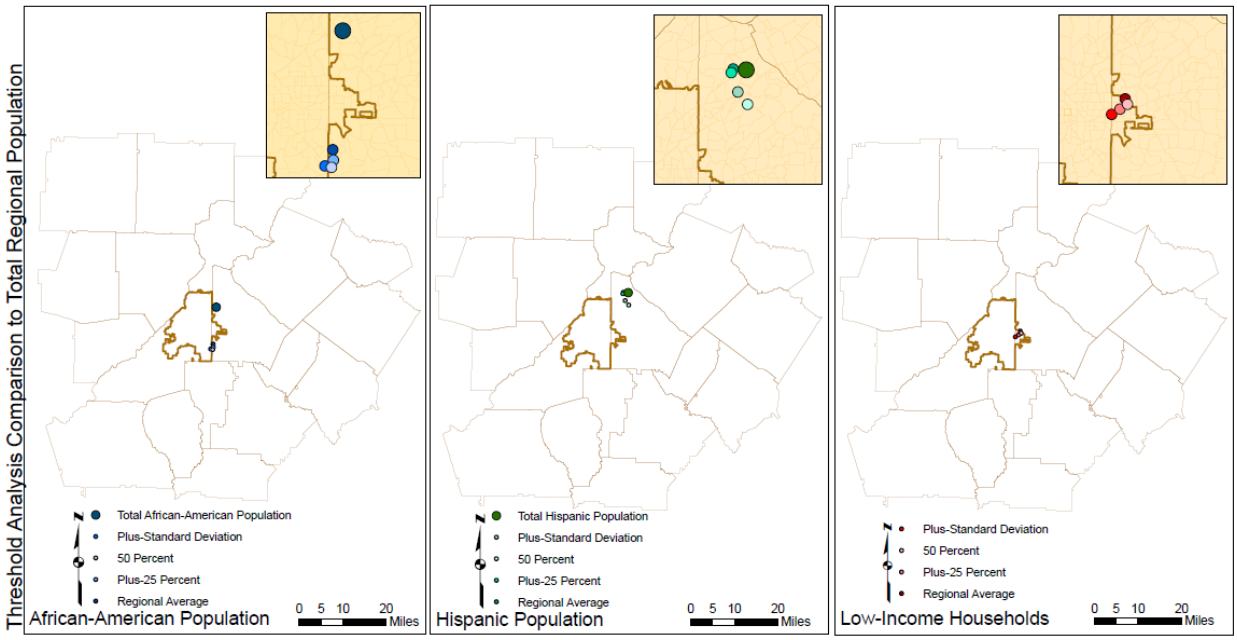


Figure 51 Comparison of mean centers for thresholds and total populations of African-American, Hispanic and low-income residents

Secondly, current methods do not contain flexibility for more precise analysis. Target populations are evaluated in aggregate, not supporting the needs of each population. The proposed method has the ability to evaluate demographic segments individually and also to explore effects on demographic segments that may not have been initially defined as target populations.

An additional limitation in practice is the focus on target populations. Impacts on target populations must be evaluated as per federal regulations. Environmental justice regulations focus on these populations as the result of historical marginalization. It is also important to understand the ground truth as to who is physically disadvantaged given a particular impact. This information is not always present when evaluating areas with high concentrations of target populations, but if areas with high or low impacts are delineated and then evaluated for their demographic profiles, the impacts on various populations can be determined.

More holistically, focusing on target areas as opposed to the actual traveling public is problematic (e.g. the modifiable area unit problem and the ecological flaw of inferencing group performance based on performance of a spatial unit). Still, it is not pragmatic to propose a method that requires micro-level analysis focused on individuals

or each tract so there must be some level of aggregation for a practice-ready application. For this research, the aggregation is not based on the demographic profile, but on the impact assessment. Rather than producing a threshold based on demographic data, areas for analysis are based on the level of accessibility (i.e. high, medium, and low). These areas are used to better understand the types of populations that experience different levels of accessibility and inform investment decisions. High, medium and low impact areas can be examined for their demographic composition and can also be explored based on factors that influence accessibility (vehicle ownership, job mismatch, etc.). The following section discusses how areas of high, medium and low accessibility were determined.

6.3 Impact Assessment

The transportation system impact that is analyzed for this research is accessibility. It has been argued in this research as well as by Martens, Golub and Robinson (2012) that accessibility, or the ease of reaching destinations, is the primary benefit of a transportation system, which makes it an important metric for equity evaluation. Further discussion on the rationale for applying this benefit to the analysis and background on the accessibility is provided in Chapters 2 and 3.

Unlike the demographic analysis, the impact assessment did not evaluate and compare multiple methods of measuring accessibility. The purpose of the impact analysis was not to test methods for assessing accessibility but to apply one method to measure accessibility for the Atlanta region so that the results could be used in the equity evaluation. Various methods for measuring accessibility are described in Chapter 3 along with a detailed explanation of the process used for this research.

Although only one method was used for the impact assessment, it is beneficial to understand how ARC measures accessibility. The Technical Assessment published by ARC (2015) provides several maps on accessibility. A set of maps was produced to provide examples of transit travel times to the 14 regional centers of the Unified Growth Policy Map that is shown in Figure 52. Figure 53 and Figure 54 are examples of the travel time maps and show average transit travel times to Midtown and Cumberland regional centers. The assumption that the regional centers are areas of intense regional

opportunity is based on the high concentration of regional jobs in these areas. This neglects other jobs and services that are more dispersed throughout the region but also establishes jobs as the primary desired destinations. By using regional centers, accessibility for the whole region is estimated and a regional view of accessibility for all TAZs is obtained using land use and transportation inputs.

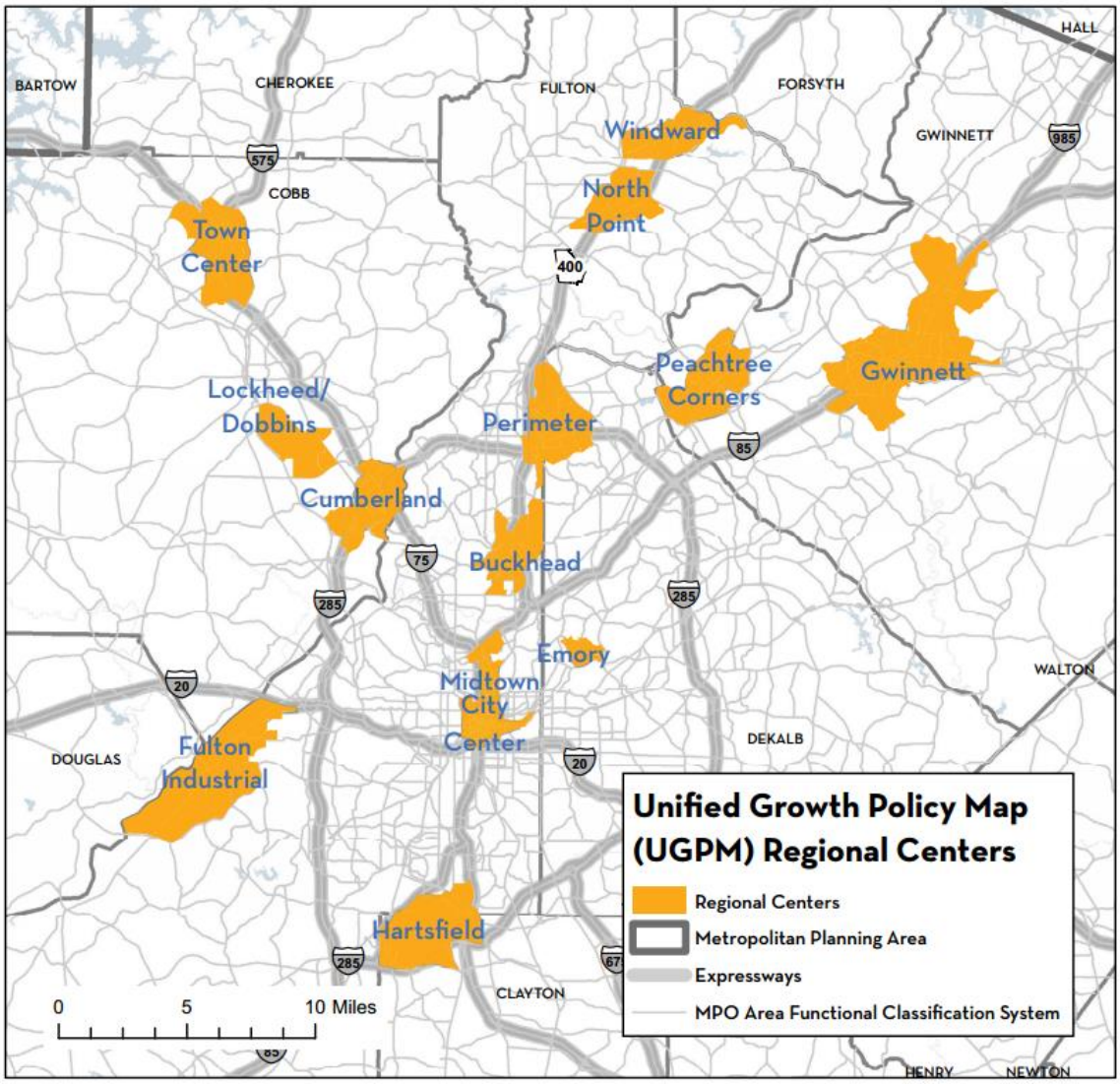


Figure 52 Atlanta metropolitan regional center based on the Unified Growth Policy Map (ARC 2015a)

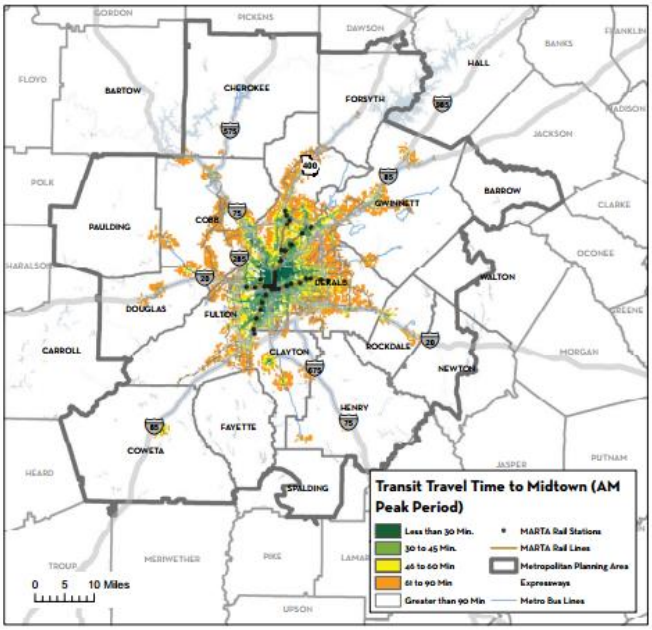


Figure 53 Average travel time to Midtown regional center based on AM peak travel (ARC 2015a)

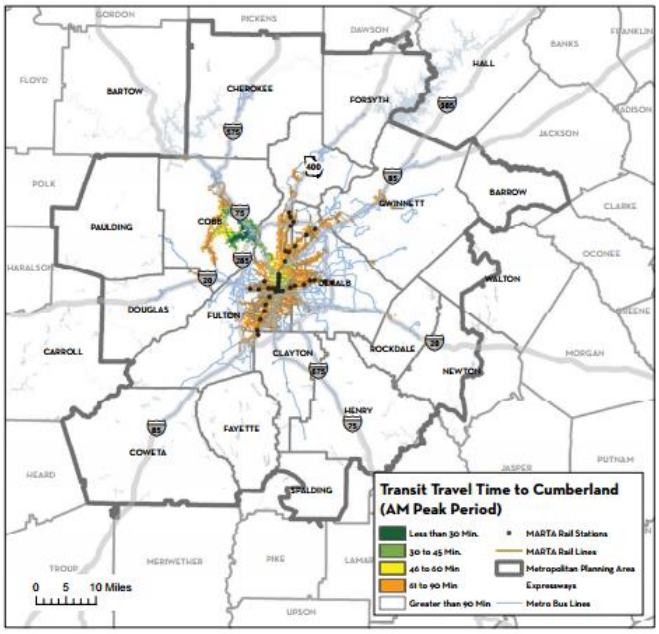


Figure 54 Average travel time to Cumberland regional center based on AM peak travel (ARC 2015a)

Transit travel time data acquired from ARC and similar to that used to develop Figure 53 and Figure 54, was used for the impact assessment. The data presented substantial data limitations. The transit travel time data was missing values for many of the TAZs and was restricted to MARTA service areas (Fulton and DeKalb Counties) with

limited information on service in Gwinnett County. Additionally, despite being adjacent to regional centers, some TAZs were not considered accessible because of the missing data. These limitations are more clearly seen in Figure 55 that shows the levels of accessibility for transit (and auto) applying the process detailed in Chapter 3. Attempts to obtain an updated set of data were unsuccessful so the available data was used. Using this data set is a limitation for applying the findings to decision making for this specific case; however, it does not compromise the application of the results in the equity evaluation to draw broad conclusion about the methods.

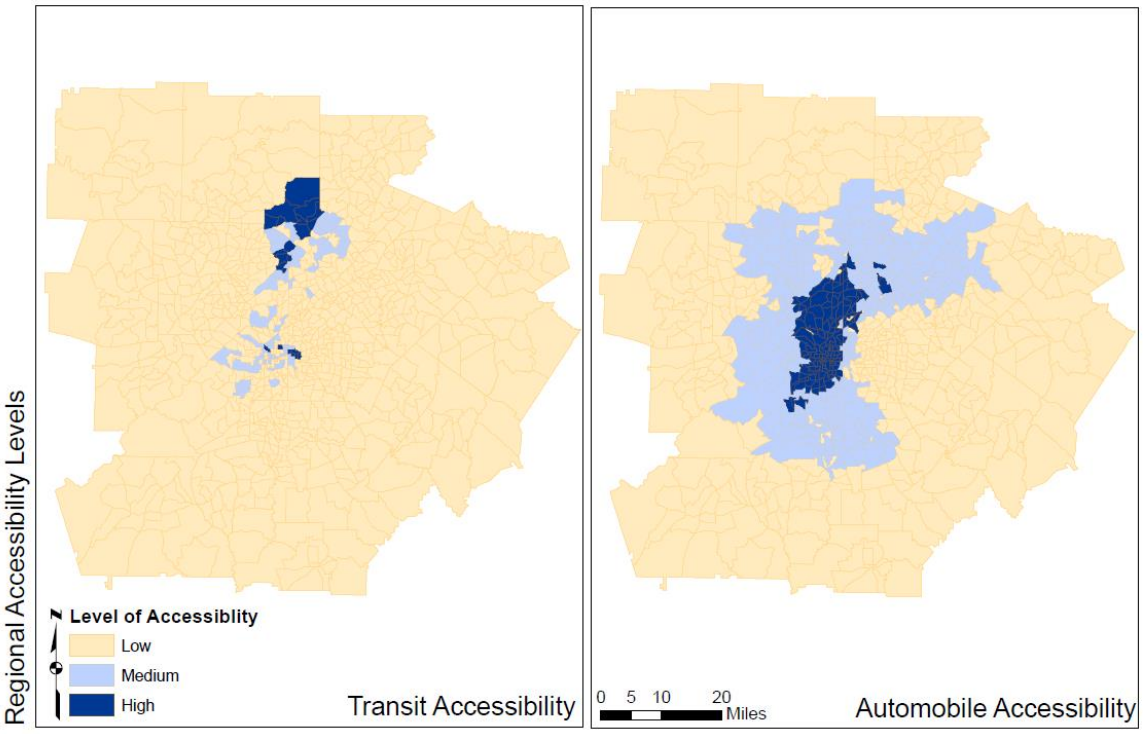
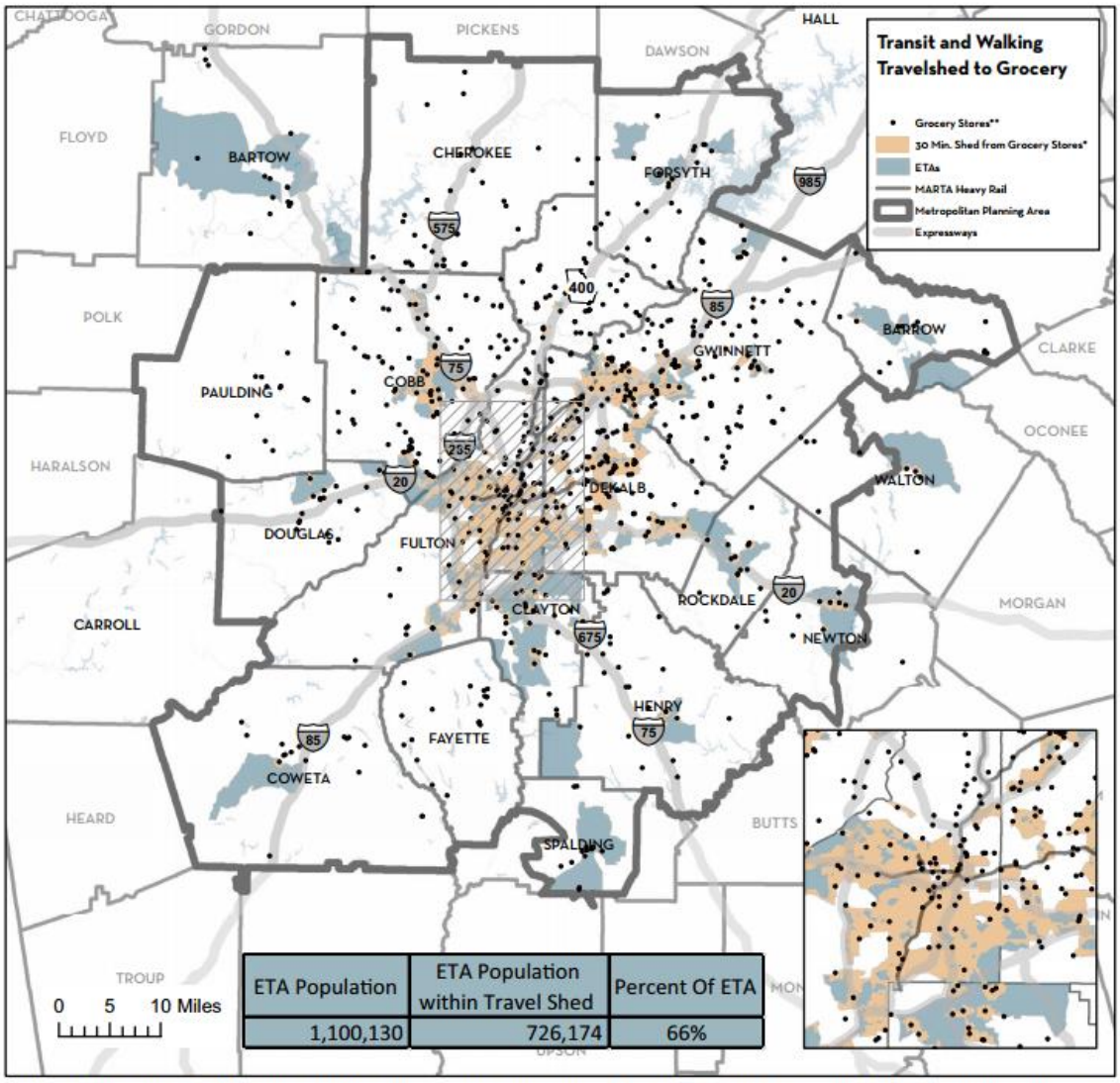


Figure 55 Regional accessibility of 18 county ARC planning area for transit and automobile

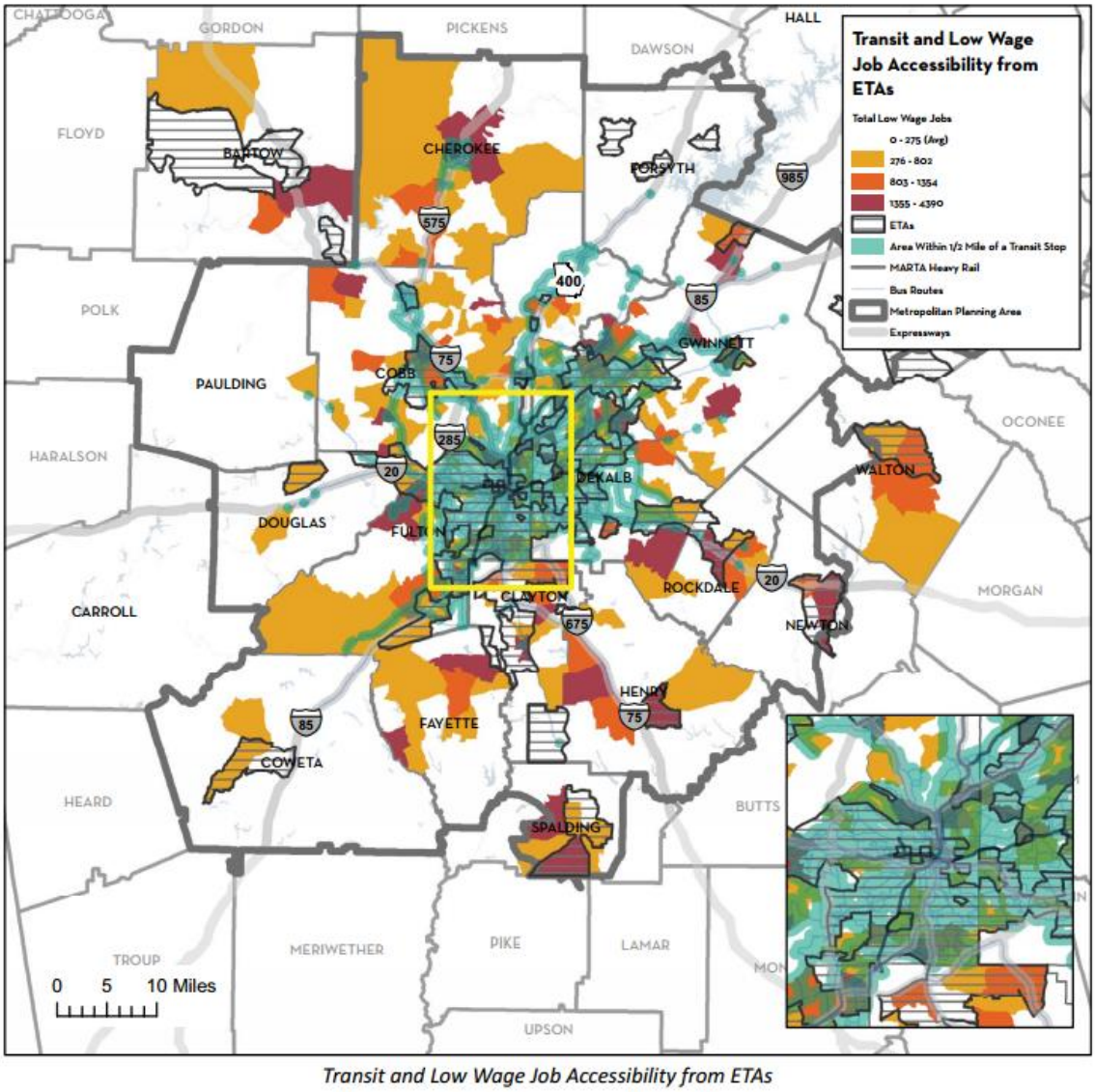
ARC also produced another set of maps that assess transit travel sheds to locations such as hospitals, libraries, educational institutions, grocery stores and low-wage jobs. These maps compare the accessibility of an extended array of opportunities specifically to ETAs. There is a map for each type of opportunity showing a buffer that represents the distance that can be traveled via transit within a given travel time to each individual destination. The resulting travel sheds are essentially a destination-based accessibility measure. The travel sheds are overlaid onto the ETAs (e.g. Figure 56 and Figure 57) to determine what opportunities are accessible for the target areas. The maps

attempts to understand what opportunities are actually available via transit. The narrowed scope of these maps focus on individual opportunities and a subset of the population, which constricts the evaluation of regional impacts, but the specificity provides a better understanding of what opportunities are actually accessible.



*Shed assumes up to 1 kilometer walking averaged on each end of the transit trip. **Grocery Store definition from NACIS and sale volume of at least 3,500,000. An equal distribution of population throughout ETA Census tracts is assumed for ETA population share estimates.

Figure 56 Areas within 30 minutes transit and pedestrian travel time to grocery stores compared to Equitable Target Areas. Accessibility to hospitals, libraries, and educational institutions were determined in the same manner. (ARC 2015a)



Transit and Low Wage Job Accessibility from ETAs

Figure 57 Transit accessibility to low wage jobs based on proximity to transit stops (ARC 2015a)

ARC's use of both sets of maps highlights the difficulty in understanding real versus perceived accessibility, as explained below. Accessibility is based on the transportation system as well as the destinations that can be reached via the transportation system. Transportation planning, however, often focuses on the transportation system and typically assumes that the presence of certain destinations equates to an opportunity. "Real opportunities" describe destinations that improve the quality of life for residents. Health care facilities, schools, grocery stores and other destinations that provide for the basic needs of the residents of the region represent real opportunities. Accessibility analyses such as the one conducted in Figure 56 begin to account for such opportunities.

Jobs are also important to quality of life; however, analysis methods with little regard to capabilities of the people who can travel to these employment opportunities (i.e. if they have qualifications and/or ability to work in the jobs) rely on "perceived opportunities." For example, ARC perceives the regional centers as desired destinations, because the high level of jobs in these areas is assumed to translate to high opportunity for all residents. To determine real opportunities requires sophisticated accessibility measures and will likely necessitate improvements to the existing measures. Addressing the difference between real and perceived opportunities requires ways to draw connections between the population and opportunities, parsing out the opportunities that are actually accessible from the universe of opportunities that exist. Developing such a measure was outside the scope of this research; however, the additional precision of the proposed method for equity evaluation provides an opportunity to evaluate impacts on specific populations and potentially draw connections to specific opportunities.

The process used to measure accessibility in this dissertation establishes the regional centers as the opportunities of interest. In addition to transit accessibility, automobile accessibility to 13 regional centers from each TAZ of the 18-county MPO was calculated. An average travel time was used to create an accessibility score for each tract based on the distinctions used in PLAN2040. The travel times and associated levels of accessibility are shown in Table 27. Any score of zero was considered low accessibility, otherwise the tract has either medium or high accessibility. Tracts with a score of 1 (medium access to 1 regional center) or 2 (high access to 1 regional center or medium access to 2) were categorized as medium accessibility. Tracts that had accessibility scores that reflect access to multiple regional centers (3 or higher) were categorized as having high accessibility.

Table 27: Accessibility Scores and Corresponding Travel Times

	Level of Accessibility		
	High	Medium	Low
Mode			
Transit	<25	25-45	>45
Car	<10	10-30	>30
Score	2	1	0

The limitations of accessibility measures are discussed in detail in Chapter 3 along with the limitations particular to the method used in the impact assessment. The limitations for the impact assessment primarily concern data constraints and reconciling across spatial units. Additionally, because it was not the foremost aim of this research to produce an assessment of accessibility for the Atlanta region, nor was it to develop an accessibility measure to address limitations in practice, the results of the impact assessment represent an estimated picture of accessibility in the region and should not be used as conclusive evidence on the accessibility for the Atlanta metropolitan area. The results, however, can serve to explore how equity may be evaluated. Despite the limitations, by using this estimate of accessibility consistently in the equity evaluation, the primary aim of exploring equity evaluations is reached. This is achieved by using the results of the impact assessment in concert with the demographic analysis. The process for the equity evaluation is discussed in the following section.

6.4 Equity Evaluation

Equity is a pluralistic concept and depending on how it is viewed, the definition will differ. This leads to complications in measuring equity because, depending upon the context, it is difficult to say whether a situation is more or less equitable. For this reason, this research does not "measure" equity but evaluates equity by identifying gaps in performance and producing information useful for planning decisions. Focusing on performance gaps not only removes the need to make a definitive statement on whether outcomes are equitable, but it provides more information for consideration in planning decisions. With this information, the needs of residents and of the transportation system

can be assessed, needed improvements can be highlighted and investments can be made to address deficiencies.

Equity evaluations generally compare the average impact on a target population to that on a reference population in order to comment on whether investments are or are not equitable. This is done in two ways: by applying a rational method or by comparing the percentages of populations impacted (to each other or to populations that are not impacted).

Rational methods are found primarily in the literature and are not commonly used in practice. To examine the ability of rational methods to address gaps in equity evaluations, three different indices were applied to evaluate impacts for the African-American, Hispanic and low-income populations. The Buffer Comparison Index (BCI), Area Comparison Index (ACI) and Population Comparison Index (PCI) are explained in detail in Chapter 3. The results from all three indices, show that all three target populations are underrepresented in the high and medium accessibility areas for transit and over-represented in high and medium accessibility areas for automobiles. Similar to the sensitivity analysis for thresholds, Table 28 compares and contrasts the rational methods and shows how the ratios differ. The results also reflect an important point on reference populations; similar to thresholds, the reference population selected for the analysis may influence the results substantially. The Buffer Comparison Index (BCI) shows that African-American, Hispanic and low income populations are underrepresented in medium and high transit accessible areas in comparison to all other populations; the inverse is shown for auto accessibility. This index uses the regional population as the reference population. The Area Comparison Index (ACI) shows underrepresentation of target populations in transit accessible areas in comparison to target populations in less transit accessible areas, and the opposite in auto accessibility. ACI is a comparison between areas of impact where the reference population is the population with low accessibility. The Population Comparison Index (PCI) shows

underrepresentation of target populations in transit accessible areas compared to all other populations, and again, the inverse for auto accessibility. PCI uses non-target populations as the reference population. The PCI is the most sensitive to differences between target populations and non-target populations and it reflects the greatest underrepresentation (transit) and the greatest over-representation (auto).

Table 28: Disproportionality of Target Populations in Areas of High and Medium Accessibility for Transit and Automobile using Rational Method Indices

Transit Accessibility			
Rational Method	African-American	Hispanic	Low-Income
BCI	0.803	0.651	0.588
ACI	0.848	0.656	0.702
PCI	0.787	0.629	0.563

Auto Accessibility			
Rational Method	African-American	Hispanic	Low-Income
BCI	1.064	1.383	1.036
ACI	1.083	1.916	1.038
PCI	1.128	2.070	1.069

The rational methods clearly measure disproportionality, the third and final component of quantitative analysis for environmental justice outcomes. In the process however, they reduce equity evaluations to one numerical output, providing no information about the distribution of impacts and making the assumption that a balanced proportion of target population and reference population is equitable. These indices do not address the gaps that have been identified.

A second method to determine disproportionality, the one shown throughout the case studies and commonly seen in practice, is to compare the impacts on target populations to the impacts on a reference population. This is done by comparing the impacts on target areas to a reference population, generally the regional average. First, this research tested the thresholds explained in the demographic analysis section for their influence on the equity evaluation. Similar to the sensitivity test that analyzed how the delineation of target areas was affected by the thresholds, the impact of accessibility on

target populations was tested based on thresholds. By using the target areas from the demographic analysis in conjunction with the impact assessment, accessibility for each target area was examined and led to conclusions similar to those in the demographic analysis. Table 29 compares the number of tracts and population of the target areas with high or medium accessibility. The results for auto accessibility correlate closely with the results from the demographic analysis. For transit accessibility, the results follow a similar pattern but with a different magnitude. This is likely because the region has a substantially higher level of automobile accessibility than transit accessibility (52% of tracts have high or medium auto accessibility, 11% have high or medium transit accessibility). In both cases, the results further serve to highlight that different thresholds produce different results.

Table 29: Target Populations in High and Medium Accessibility Areas based on Thresholds

Thresholds	Number of Tracts with High or Medium Accessibility	Target Population with High or Medium Accessibility	Total Population of Target Area with High or Medium Accessibility
African-American Population - Transit			
Regional Average	38	88,713	121,795
Plus-25%	35	84,202	109,638
Plus-Standard Deviation	24	65,965	74,182
50% of unit	30	76,025	91,593
No Threshold	97	123,213	429,489
African-American Population - Auto			
Regional Average	189	606,529	896,083
Plus-25%	162	548,671	740,834
Plus-Standard Deviation	107	406,354	471,479
50% of unit	141	503,098	640,927
No Threshold	463	836,007	2,404,541
Thresholds	Number of Tracts with High or Medium Accessibility	Target Population with High or Medium Accessibility	Total Population of Target Area with High or Medium Accessibility
Hispanic Population - Transit			
Regional Average	14	14,267	71,985
Plus-25%	10	12,166	54,459
Plus-Standard Deviation	3	5,404	15,258
50% of unit	0	-	-
No Threshold	97	31,343	429,489
Hispanic Population - Auto			
Regional Average	167	268,689	978,259
Plus-25%	142	248,693	811,800
Plus-Standard Deviation	85	189,387	476,078
50% of unit	18	63,299	102,914
No Threshold	463	344,517	2,404,541
Thresholds	Number of Tracts with High or Medium Accessibility	Target Population with High or Medium Accessibility	Total Population of Target Area with High or Medium Accessibility
Low-Income Families - Transit			
Regional Average	37	17,069	26,088
Plus-25%	29	13,278	18,370
Plus-Standard Deviation	17	7,568	9,430
50% of unit	33	15,228	22,168
No Threshold	97	32,012	100,361
Low-Income Families - Auto			
Regional Average	243	176,293	266,897
Plus-25%	195	141,542	197,445
Plus-Standard Deviation	119	84,447	105,937
50% of unit	222	162,052	236,467
No Threshold	463	255,032	564,232

To apply a process similar to those used in practice, the combined target area for minority and low-income populations (union) based on the regional average threshold, ARC's ETAs and the total region without target areas were compared for the percentage of target population with high or medium accessibility. In a fashion similar to MPOs such as BRMPO and MTC, the target populations were compared to a reference population: the regional average. The results are compared in Table 30. The results further

highlighted the impacts of target areas on equity evaluation results and also showcase the impacts of aggregating target populations.

Table 30: Equity Evaluation for Transit and Auto Accessibility of Target Populations based on Standard Practice

Measures for Determining Target Population	Reference Population	Target Populations		
	Regional Population	African-American Population	Hispanic Population	Low-Income Population
		Transit Accessibility		
Regional Average	9%	6%	3%	4%
Equitable Target Areas	9%	4%	1%	2%
No Threshold	9%	7%	6%	6%
		Auto Accessibility		
Regional Average	48%	45%	55%	38%
Equitable Target Areas	48%	23%	30%	19%
No Threshold	48%	50%	64%	47%

Comparing the target areas based on the regional average threshold and the ETAs, the ETAs have a smaller percentage of target populations with high and medium accessibility but both, as expected, capture less of the populations within high and medium accessibility than there are throughout the region. For equity evaluations like those used in practice, the percentage of the target population is compared to the regional population with the goal of parity. Based on the threshold, this comparison is different, further showing the influence that the threshold chosen has on the equity evaluation. The results here also show that by not using a target area, automobile accessibility is on par or above that of the region. The equity evaluation is much different for auto accessibility based on the thresholds, which exhibits the difference between evaluating impacts on the regional target population and the target population based on target areas.

The proposed method for equity evaluation assesses the distribution of impacts on the full population of various demographic segments. The proposed equity evaluation also focuses on the disadvantaged population to analyze the demographic composition of low accessibility areas. Finally, it focuses on gaps between high and low accessibility within a population. These analysis methods align with Rawlsian distributions, specifically the maximax principle. The process is guided by this principle and compares

the most and least advantaged in terms of accessibility. This comparison helps identify the minimum standard of performance that can be used in tracking outcomes over time. The distance between the minimum and maximum impacts is also tracked and monitored over time for use in planning and decision making.

The proposed equity evaluation goes beyond identifying the gap in impacts and exploring demographic effects. It requires that the results are compared over time to determine if gaps lessen or increase and if affected populations change. The results are not used to make a statement on equity, but instead to influence decision making and policy creation in such a way that equity is included as a factor in long-range regional planning.

After applying the standard practice for equity evaluation, the proposed method was applied to evaluate equity of accessibility in the ARC planning region. For minority and low-income populations as well as elderly residents, residents without a high school diploma, and zero-vehicle households, the distribution of accessibility was expressed in three ways (Figure 58). The percentage of each population in low, medium and high accessibility areas was compared across populations, this percentage was also compared within each populations, and the areas of low accessibility were examined for their demographic composition. Bar charts and point charts were used to visually display the results.

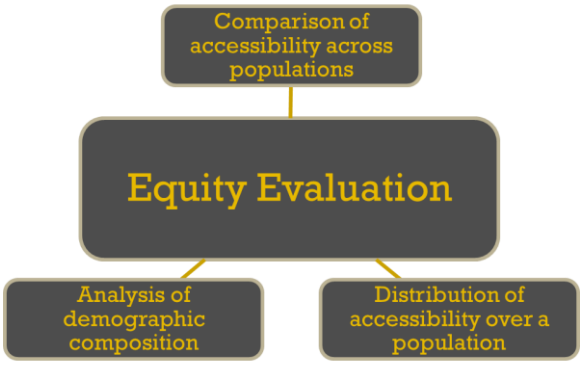


Figure 58 Comparison methods for proposed equity evaluation

Figure 59 and Figure 60 compare accessibility across populations. These charts show the percentage of the total regional population for any demographic segment that lives in a tract with either high, medium or low accessibility for transit in Figure 59 and

for automobile in Figure 60. The charts compare the distribution of accessibility for each population to each other population as well as to the regional population. This process is similar to how PSRC examines their opportunities. This type of evaluation is useful for environmental justice analyses because it helps understand disproportionality between populations; however, it is especially helpful in identifying which populations have high percentages of their total population in low accessibility areas. It also shows how the benefits are distributed across each population. The differences in how accessibility is distributed to each population can be seen. For example, the Hispanic and the low-income populations have similar distributions for transit accessibility, with Hispanic residents having just slightly more of their population in high accessibility areas. This distribution is quite different for the white population that has a greater portion of their population in high and medium accessibility areas. Distributions for auto accessibility are fairly similar across the various groups with the exception of the Hispanic population where approximately 65% reside in high or medium accessibility areas.

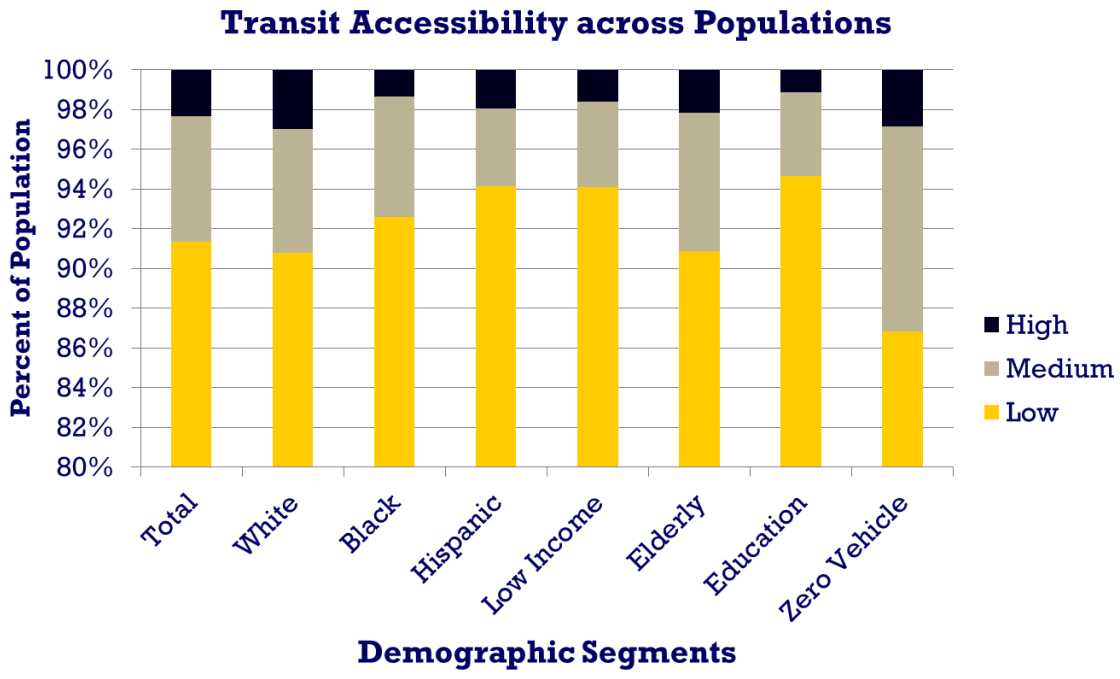


Figure 59 Levels of transit accessibility for various demographic segments. Note the y-axis does begins at 80%.

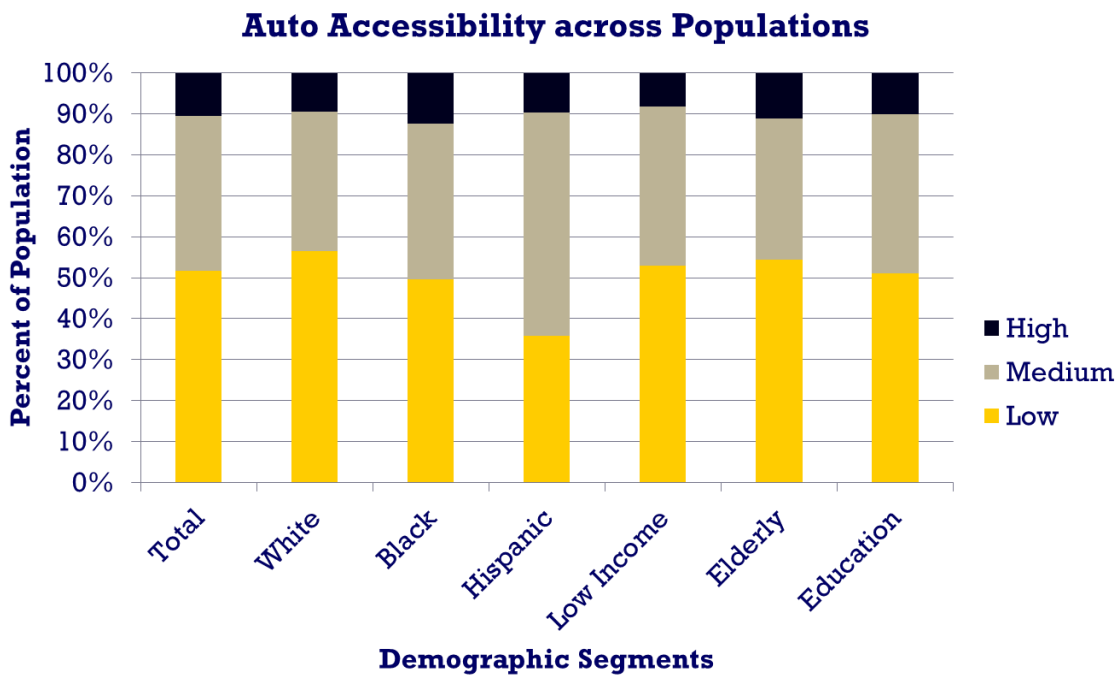


Figure 60 Levels of auto accessibility for various demographic segments

The charts can also be used to make broad observations such as the relatively high variability of high and medium transit accessibility between different demographic segments. More specifically, this information can help identify gaps between demographics segments, pointing out if certain populations have a strikingly different distribution. Similarly, low accessibility across populations can be examined and can provide information on what populations are least advantaged. These differences may help to identify populations that are not benefiting from the basic needs that the transportation system provides.

From Figure 59 and Figure 60, it is observed that zero vehicle populations have the highest levels of transit accessibility and with the exception of the Hispanic population, which was mentioned before, the level of low auto accessibility is comparable across all populations. This suggests that some minimum standard for automobile access has been reached across all populations or that there is limited disparity across populations in terms of low auto accessibility. The transit accessibility tells a different story; as mentioned there is greater variation and Hispanic, low income and limited education populations have the highest percentages of low accessibility.

Separating transit and auto accessibility provides insights, especially in a transportation system that has limited transit accessibility. The disaggregation of data across demographic segments helps to support the finding that target populations are impacted differently.

Since the comparisons in Figure 59 and Figure 60 are based on normalized results, Table 31 provides context by showing the total population in each demographic segment. Additional context is provided by Figure 61 and Figure 62. The charts show each target population and the percentage of the total regional population they represent, the percentage of all people in the region with high/medium accessibility and the percentage of the regional population with low accessibility. This helps to understand the demographic composition of areas of low accessibility. The demographic groups overlap so the total percentage of the chart does not equal zero. The chart allows a comparison of the representation of each target population in areas of low accessibility, high/medium accessibility and the region. If accessibility is perfectly equal across the region, these three bars will also be equal. For auto accessibility for low-income, elderly and limited education populations, it is nearly equal.

The focus of Figure 61 and Figure 62 is to identify patterns where there is a greater percentage of the demographic segment in low accessibility than in the region or in high/medium areas (e.g. auto accessibility for the white population). This information can be used to identify population segments for further examination to better understand their needs in contextual analyses. For instance, contextual information can show that there is low accessibility because of land use patterns or that there is low auto accessibility but high transit accessibility. This information is useful for future planning.

Table 31: Total Regional Population by Demographic Segment

	Region	White	African-American	Hispanic	Low Income	Elderly	Education	Zero Vehicle
Total Regional Population	4,970,225	2,683,126	1,659,297	536,332	542,191	433,208	384,632	112,344

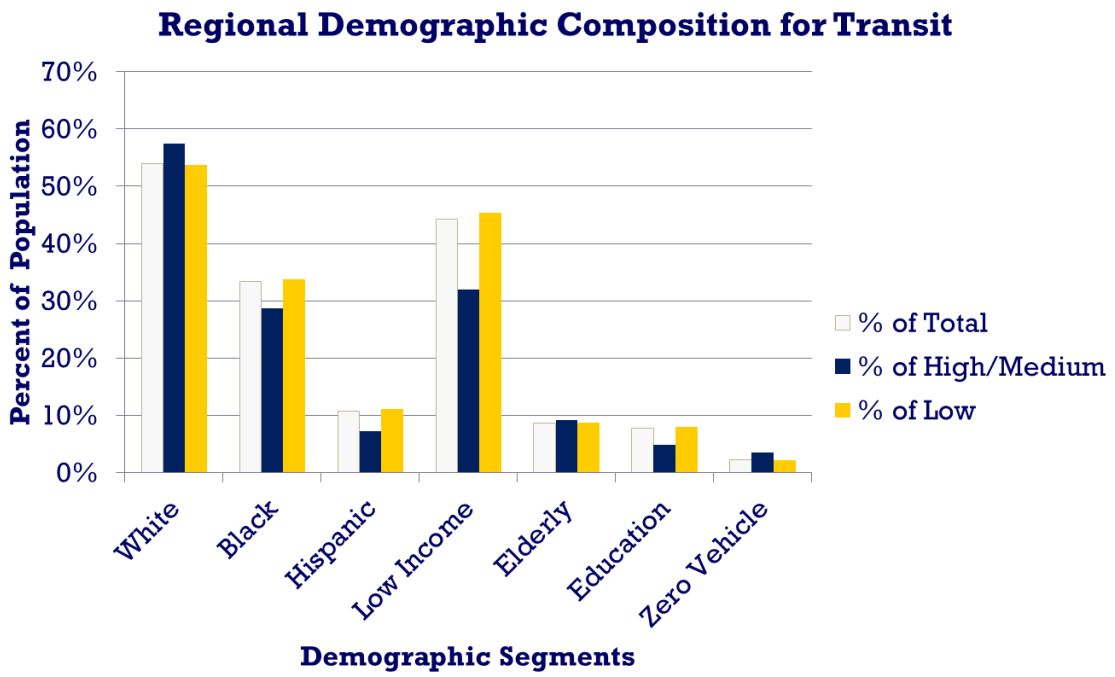


Figure 61 Demographic composition of region and regional areas of high/medium and low transit accessibility

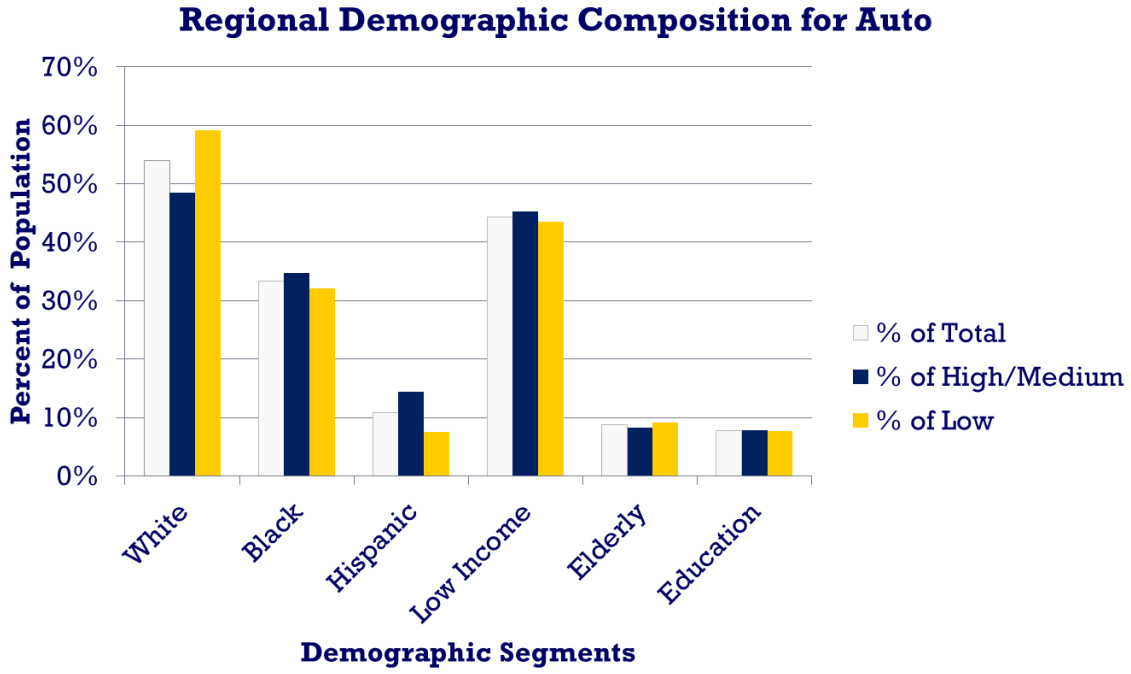


Figure 62 Demographic composition of region and regional areas of high/medium and low auto accessibility

Figure 63 and Figure 64 present data similar to Figure 59 and Figure 60 but represent the information differently. Points are associated with the percentage of each target population in high, medium or low accessibility areas. The information more clearly shows the gaps between the levels of accessibility. Although the points are connected by lines, they are not representative of a trend and are included to make the points more visible. The gaps for auto accessibility have greater variability than those for transit. On closer examination of auto accessibility, the percentage of high accessibility is similar across all populations; however, the percentage of low accessibility changes, especially for the Hispanic population. For transit access, there is a large gap for all populations because of the low level of transit accessibility. Still, the gap between high and low accessibility for zero-vehicle households is the smallest. Although this finding is logical and reassuring, the important component of this evaluation is to track this gap over time in order to improve the ability of the transportation system to meet the needs of these households more completely. In tracking these results over time, the gaps between these dots can be compared and performance towards equity can be judged based on how the gap narrows or widens. Figure 63 and Figure 64 can also be evaluated over time for the location of the low accessibility point to determine whether the percentage of the population in low accessibility areas increases or decreases. This will show how the disadvantaged population has been affected by transportation improvements over time.

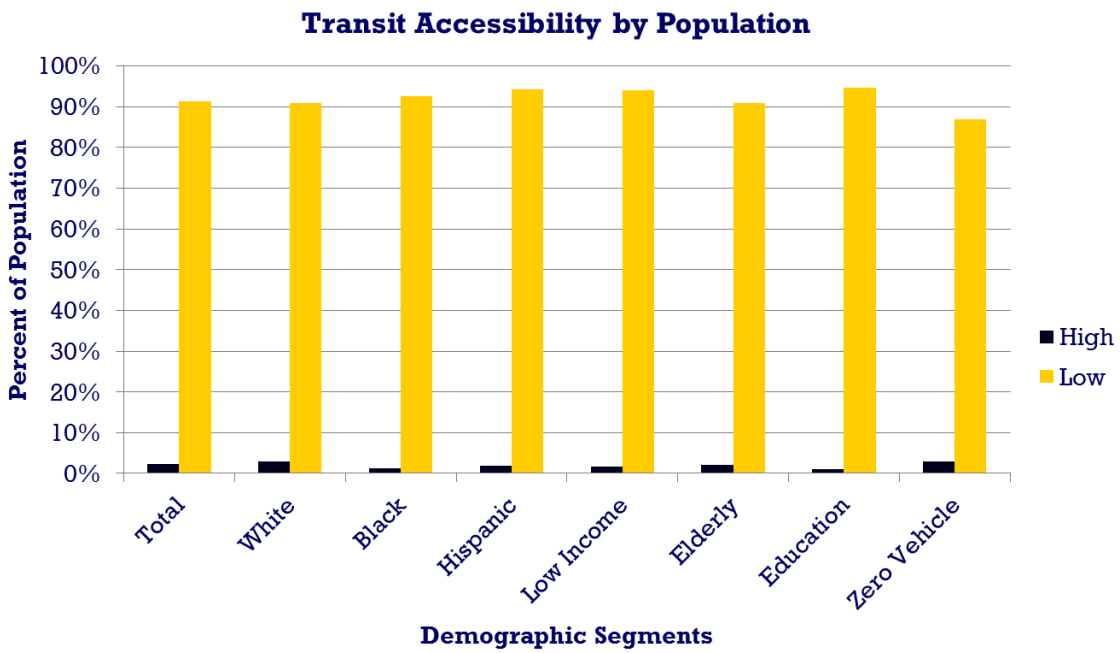


Figure 63 Gaps in transit accessibility for each demographic segment. Note the lines do not represent trends and are included only for visual clarity.

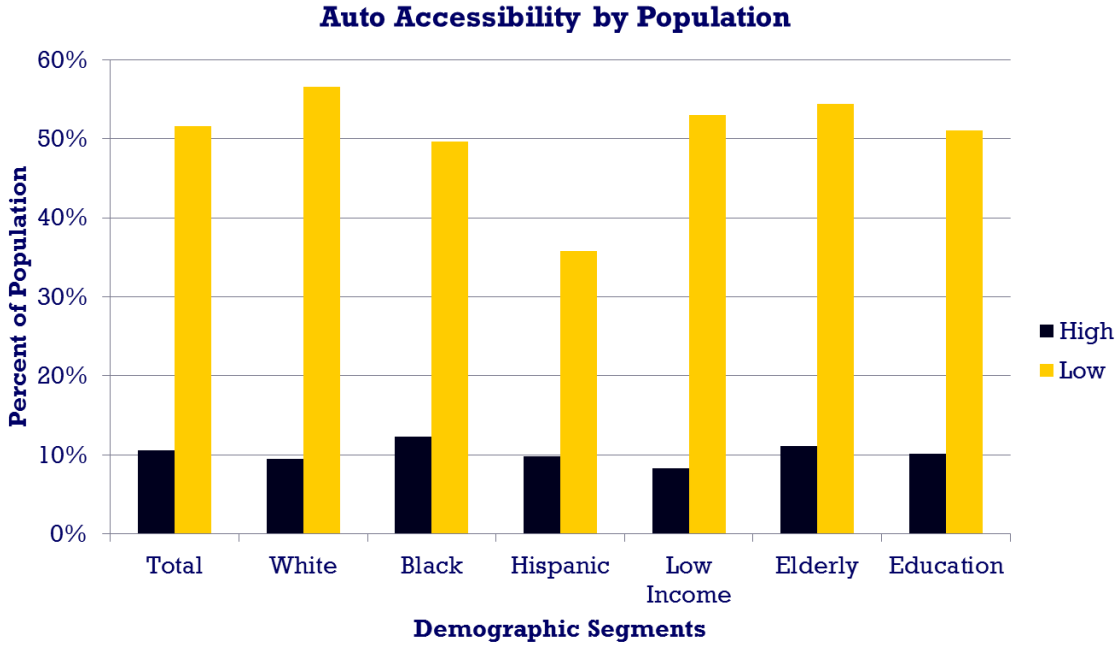


Figure 64 Gaps in auto accessibility for each demographic segment. Note the lines do not represent trends and are included only for visual clarity.

With the information provided from the proposed equity evaluation methods, impacts can be compared both across and within populations. Populations can be compared separately, allowing for more precise information and a better understanding of how target populations are impacted. It also allows a focus on areas or populations that are disadvantaged by impacts. The disaggregation of information allows for several comparisons to provide substantial information for decision makers. One key point from ARC's validation, however, was that decision makers and the public are interested in having "one map," essentially one graphical representation of the equity climate in the region. To produce such a graphic, information that is collected over time can be used to illustrate how accessibility levels change. It can show who is impacted and what the minimum level of performance is. Providing this summary graphic will be critical because, although the additional information is useful, it may not be appropriate for or easily interpreted by decision makers.

6.5 Conclusion

This chapter presents the findings of the analytical comparison of methods. It details the quantitative analysis of this dissertation and works to answer the research questions:

- How does one develop a demographic profile within a practical spatial unit of analysis to inform program development?
- How can one identify the level of equity of an impact across a region?

To answer these questions, the proposed method was developed and tested in comparison to standard practice to address the limitations of current methods.

For each of the three components – demographic analysis, impact assessment, and equity evaluation – standard methods were compared with the proposed approach for the context of the Atlanta metropolitan region. The results highlight limitations of standard practice and show ways that the proposed method addresses these limitations. The limitations include a focus on specific target populations and the use of target areas defined by thresholds. The ability to conduct a demographic analysis after the impact analysis rather than at the beginning of the process provides flexibility in which demographic segments can be examined. In fact, effects on any demographic segment

can be explored in the proposed method. Additionally, the proposed method eliminates the use of thresholds based on population concentrations and does not delineate target areas, which have been show to impact the evaluation.

The proposed method does not require comparison to a reference population. The results provide that option but the equity evaluation is not dependent on it. Neither is it dependent on average impacts. The proposed method provides information about the distribution of the impact for comparison instead.

Finally, the proposed method collects and compares data over time to develop a picture of accessibility returns and cumulative benefits. By comparing gaps in performance across demographic segments over time, deficiencies and equity concerns will become clear. What is important to remember is that this information does not give an answer to the question of whether impacts are equitable or not. Rather, what it provides is information that can be used to make decisions to promote equitable outcomes. How this information can be incorporated into decision making is discussed in Chapter 7.

CHAPTER 7

RECOMMENDATIONS AND CONCLUSION

7.1 Introduction

Transportation planning has become increasingly more performance-based over the past several decades and the 2012 Federal Surface Transportation Program authorization, Moving Ahead for Progress in the 21st Century (MAP-21), formalized a performance-based policy and programmatic framework for transportation investment. It follows that metropolitan long-range planning is now required to integrate seven national goals into investment decisions using performance management principles. Although equity is not a national goal, agencies continue to recognize it within their vision and planning goals, usually in the context of sustainability. As agencies implement performance-driven decision making as a means to achieve national goals, local goals will become subject to the same framework.

In order to use equity goals in a performance-based planning framework, it is necessary to have suitable methods to evaluate performance towards these goals. Equity is often not measured, in part because it is difficult to evaluate. Current methods for measuring equity are found in environmental justice analysis; however, this method has important limitations with respect to achieving equity of transportation outcomes. These limitations have been discussed in detail in this dissertation. In addition to the limitations of methods for analyzing equity, there are also gaps in how equity is being incorporated into the planning and decision-making process. These issues have been explained in detail as well. The limitations and gaps are:

Methods

- Analytical methods for evaluating environmental justice outcomes narrow the scope of equity to specific target populations
- Target areas do not provide a complete picture of target populations

- Equity evaluations neglect the pluralistic nature of equity and determine if a given impact is distributed equitably by comparing the average impact for target populations to the average impact for a reference population
- Analyses of equity outcomes do not account for or include cumulative impacts and lack continuity over planning cycles

Planning

- Results of environmental justice analysis are used as a final check of compliance and are not incorporated into decision making
- Equity is not often established as planning goal
- Performance measures for equity are difficult to define
- Procedures to promote equity in transportation planning do not connect to equity outcomes

This dissertation explored methodological limitations and planning gaps related to transportation planning for equitable outcomes. It initially identified the gaps in the literature, then conducted case studies to catalogue practical applications of equity measures and the inclusion of equity in planning processes. Finally, the research proposed and applied a method of equity evaluation and compared the results to those from the state of practice methods. Based on the gaps in the literature and in practice and the ability of the proposed method to address these gaps, a set of recommendations was developed to guide transportation planning towards achieving equitable outcomes. Specific methodological recommendations are proposed as well as specific means to incorporate these into planning. This chapter presents conclusions based on each methodological limitation and planning gap identified from the research and provides recommendations for addressing them based on the findings. It then reviews the contributions of this work and identifies areas for future research.

7.2 Methodological Limitations and Recommendations

There are limitations in the quantitative and analytical methods used to evaluate equity in the transportation context. First, analytical methods used to evaluate environmental justice outcomes narrow the scope of equity to specific target populations.

The focus on historically disadvantaged populations accounts for the needs criteria of social justice; however, planning for public goods encourages the application of the equality criteria as well. Equity evaluation therefore, should assess impacts across all populations while still providing the opportunity to understand impacts on target populations. Target populations can continue to be analyzed by conducting regional impact assessment and analyzing all populations with a particular interest in effects on target populations. Such a process provides flexibility which is important because, as shown in the case study review in Chapter 4, a variety of target populations may be selected for evaluation. The case study review also showed that MPOs may use additional methods outside of environmental justice to include equity in decision making. The method for equity evaluation proposed in this research can be used to analyze impacts on any demographic segment, providing the opportunity to evaluate impacts on target populations and to obtain additional information on equity for planning.

There are also limitations in using target areas. Target areas do not provide a complete picture of the target populations. Target areas favor high concentrations of target populations and will therefore miss portions of the target population that do not congregate. They are also sensitive to the threshold used to delineate them. MPOs often struggle with the process of selecting an appropriate threshold. Analysis in Chapter 6 showed that thresholds are sensitive to the concentration, location and size of populations. Furthermore, by creating geographic representations of populations, target areas are subject to the Modifiable Area Unit Problem (MAUP) and the ecological fallacy of inferring group performance from the average performance of a spatial unit. Limitations for using target areas are further complicated when target areas are developed with aggregated demographic attributes, assuming all target populations are impacted similarly. Although MPOs that use target areas aggregate them, this research has shown that target populations are affected differently. Reliance on geographic representations of population segments should be reduced and impacts should be evaluated on the distribution of the population and not just areas of high concentration. These impacts should be evaluated on disaggregated demographic segments and across the entire population. Target areas limit the analysis of equitable outcomes by focusing on specific populations in a defined area of the region. Furthermore, there are substantial limitations

in how these areas are defined. The proposed method does not rely on target areas and therefore is not subject to the complications choosing and applying thresholds and can include dispersed populations.

Standard equity evaluations neglect the pluralistic nature of equity and attempt to determine if there is or there is not equity. The answer to whether an impact is distributed equitably, however, depends on the construction of equity used. It is therefore more beneficial for equity evaluations to determine how to improve equity outcomes rather than if impacts are equitable. The results from an equity evaluation should identify gaps in performance and minimum standards of performance in order to provide useful information to decision makers on the outcomes of cumulative transportation system investments. Standard equity evaluation practices compare the average impact for target populations to the average impact for a reference population to judge equity. As shown in Chapter 6, using measures of central tendency masks the distribution of impacts on the entire population. Furthermore, comparing target populations to a reference population makes the results sensitive to how the reference population is defined. Although reference populations may provide context for the results of an equity evaluation, the comparison to a reference population limits the robustness of equity evaluations by again focusing on a single point of information and not the distribution of impacts. Some MPOs provide information on the distribution of accessibility across each target population; the proposed method applied this approach to evaluate the distribution of impacts, identify gaps and minimum performance standards and provide information for planning for equitable transportation outcomes.

Finally, standard analytical methods for equity evaluation do not account for cumulative impacts and lack continuity over planning cycles. Transportation impacts are distributed temporally, however, data on historic impacts are not used and any temporal consideration is given based on travel demand forecasts. Demand forecasts have their own limitations and assume that the population remains the same over time although populations are dynamic. Additionally, improvements to the transportation network over time accumulate to influence outcomes of the system, but these cumulative impacts are not accounted for in equity evaluations, in part because of limitations of temporal analysis. The cumulative impacts should be analyzed during each plan update by

periodically reviewing the regional impacts from historical data to understand how decision making has been impacting and can improve equitable transportation outcomes. The changes between the plan updates can then be evaluated for different demographic groups to assess equity outcomes. One of the MPO case studies has begun to recognize these limitations and even sets performance targets to evaluate equitable performance. Because the transportation system accumulates benefits with continued investment over time and equity is a function of intergenerational impacts, there must be a temporal component to evaluating equitable transportation outcomes that uses past performance to inform future decisions.

7.3 Planning Gaps and Recommendations

In addition to methodological limitations, there are gaps in incorporating equity into transportation planning. The first relates to the standard evaluation practices for environmental justice analysis. Environmental justice is the primary vehicle for addressing equity in transportation but the results of environmental justice analysis are used as a final check of compliance and are not incorporated into decision making. Environmental justice analysis is often conducted for compliance with regulations or as a part of NEPA requirements and environmental justice may be viewed within environmental review and not planning. This assertion is supported by the fact that of the MPOs studied, those that include equity in planning conduct equity evaluations in addition to environmental justice analysis. Federal guidance, however, has begun to assert that environmental justice should have a place in the planning process. Even if environmental justice is not used to incorporate equity into planning, it should not simply serve as an independent check and environmental justice analysis should be leveraged in the planning process.

Equity is often not established as a planning goal. Only some agencies incorporate equity within their vision or as a policy objective and establish a formal commitment to use equity in planning and decision making. Often equity is not considered at discrete stages in the planning process and is evaluated outside the context of other planning criteria as a check for compliance with environmental justice requirements. Equity should be established as a planning goal within a performance-

based planning framework and considered among multiple planning priorities. MPOs from the case study review that had equity as a planning priority and also implement performance-based planning had equity-related performance measures to evaluate projects or investment scenarios. Performance-based frameworks help to promote the application of equity evaluations in decision making when equity is a goal. Considering equity along with other priorities allows decisions to be influenced by equity concerns.

Performance measures for equity are difficult to define. Measuring outcomes like equity presents issues including data availability, causal linkage, and subjective valuation. In part due to measurement difficulties, equity and other social measures are lacking in sustainability rating systems. Even environmental justice evaluations have limitations in analyzing equity as discussed in several places in this research. Improved equity evaluation methods proposed by this research can be used to inform planning for equity within a performance management framework. Despite consequential limitations, MPOs rely on environmental justice-based methods to measure equity. Environmental justice analysis is not equipped to capture cumulative benefits and MPOs evaluating equity of such impacts have expanded their measurement of equity past environmental justice. Without quality measures, equity may not be included in performance management practices and will therefore not be considered in decision making. Appropriate measures to assess equity for long-range planning must be developed to evaluate cumulative impacts and address current analysis limitations. The methodological improvements proposed in this research provide measures useful for assessing equitable transportation outcomes.

Finally, procedures to promote equity in transportation planning do not connect to equity outcomes. At a minimum, all transportation agencies consider equity in planning through public outreach practices. Procedural efforts such as this support equality of opportunity but do not necessarily result in equity of outcomes. Performance-based planning recommends tying outcomes more directly to the planning process. Equity considerations should be incorporated throughout a metropolitan transportation planning process that implements performance management practices (performance measures, targets, analysis, prioritization, etc.). Equality of opportunity and equity of outcome are addressed separately but, it is possible to draw a link between the two by more clearly

connecting policy to outcomes with a planning process that monitors performance periodically, such as performance management. Equity considerations must be incorporated into the procedural process to influence equitable outcomes but policies must go beyond participatory planning to include public feedback and equity concerns in the development of the Transportation Improvement Program (TIP) and the long-range transportation plan (LRTP) in order to influence outcomes.

The methodological limitations and planning gaps are outlined in Table 32. The table includes findings from the literature review and summarizes results of the case study review and analytical comparison of methods. The findings are used to support the conclusions expressed in this chapter and develop recommendations.

Table 32: Summary of Gaps, Conclusions and Recommendations

Gaps	Background	Case Study and Methods Analysis Findings	Conclusions	Recommendations	Values of Equitable Transportation Planning
Methods	**There are limitations in the quantitative and analytic methods used to evaluate equity in the transportation context.**				
Analytical methods for evaluating environmental justice outcomes narrow the scope of equity to specific target populations.	The focus on historically disadvantaged populations accounts for the needs criteria of social justice; however, planning for public goods encourages the application of the equality criteria as well.	• A variety of target populations may be selected for analysis. • MPOs may use additional methods outside of environmental justice to include equity into decision making.	Equity evaluation must expand the analysis beyond specific target populations to apply across various populations throughout the region. Using the proposed equity evaluation method applies the analysis to any and all demographic segments. This method can evaluate impacts on target populations and also provide additional information on equity for planning.	Expand evaluation to assess impacts across all populations while still providing the opportunity to understand impacts on target populations. This can be accomplished by conducting a regional impact assessment and analyzing the experience across populations with the proposed method for equity evaluations.	• Expands the evaluation of equity to apply regionally across various populations. • Continues to address environmental justice regulations and concerns.

Gaps	Background	Case Study and Methods Analysis Findings	Conclusions	Recommendations	Values of Equitable Transportation Planning
Target areas do not provide a complete picture of target populations.	Target areas favor high concentrations of target populations and will therefore miss a portion of the target population. They are also sensitive to the threshold used to delineate them. Furthermore, creating geographic representations of populations are subject to the Modifiable Areal Unit Problem and the ecological fallacy of inferring group performance from the performance of a spatial unit. Limitations for using target areas are further complicated when they are developed with aggregated demographic attributes, assuming all target populations are impacted similarly.	• Selecting an appropriate threshold is complicated and MPOs often struggle with this process. • Populations that do not congregate are neglected in an analysis based on target areas. • MPOs that use target areas aggregate target populations. • Analysis shows equity evaluations are sensitive to thresholds based on the concentration, location and size of population. • Analysis shows that target populations are impacted differently.	Target areas limit the analysis of equitable outcomes by focusing on specific populations in a defined area of the region. Furthermore, there are substantial limitations in how these areas are defined. The proposed method does not rely on target areas and therefore is not subject to complications in choosing and applying thresholds and includes dispersed populations.	Reduce reliance on geographic representations of population segments. Evaluate impact on the distribution of the population and not just areas of high concentration. Evaluate impacts on disaggregated demographic segments and across the entire population.	• Expands the evaluation of equity to apply regionally across various populations.
Standard equity evaluation practices neglect the pluralistic nature of equity and determine if there is or is not equity by comparing the average impact for target populations to the average impact for a reference population.	The answer to whether an impact is distributed equitably depends on the construction of equity used. Furthermore, using average impacts masks the distribution of impacts on the entire population and by comparing the impacts to a reference population, the results are sensitive to how the reference population is defined.	• Some MPOs provide information on the distribution of accessibility across each target population. The proposed method applied this approach. • The sensitivity of analysis to reference populations was shown during testing of the rational methods.	Reference populations may provide context for the results of an equity evaluation, but the comparison to a reference population limits the robustness of equity evaluations by focusing on a single point of information and not the distribution of impacts. It also makes the results sensitive to the reference population selected.	Use equity evaluation to determine how to improve equity outcomes and not if impacts are equitable. Results from equity evaluation should identify gaps in performance and minimum standards of performance in order to provide useful information to decision makers on the outcomes of the transportation system.	• Expands the evaluation of equity to apply regionally across various populations. • Identifies gaps in equity outcomes and minimum level of performance.

Gaps	Background	Case Study and Methods Analysis Findings	Conclusions	Recommendations	Values of Equitable Transportation Planning
Analyses of equity outcomes do not account for or include cumulative impacts and lack continuity over planning cycles.	Transportation impacts are distributed temporally; however, data on historic impacts are not used and any temporal consideration is given based on travel demand forecasts. Additionally, improvements to the transportation network over time accumulate to influence outcomes of the system, but these cumulative impacts are not accounted for in equity evaluations, in part because of limitations for temporal analysis.	• Some MPOs use forecasted impacts but none use historical data to monitor performance over time. • One MPO set performance targets to evaluate equitable performance. • An additional gap was identified: forecasts assume populations remain the same although populations are dynamic.	Because the transportation system accumulates benefits with continued investment over time and equity is a function of intergenerational impacts, there must be a temporal component to evaluating equitable transportation outcomes that uses past performance to inform future decisions.	Conduct cumulative impact analysis by periodically reviewing the regional impacts during each plan update. Use historical performance data to understand the how decision making has and how it can improve equitable transportation outcomes. Evaluate the changes between the plan updates for different demographic groups to assess equity outcomes.	• Incorporates performance in equity over time into future planning. • Works at the program-level to plan for the comprehensive transportation network.

Gaps	Background	Case Study and Methods Analysis Findings	Conclusions	Recommendations	Values of Equitable Transportation Planning
Planning	**There are gaps in incorporating equity into transportation planning.**				
Results of environmental justice analysis are used as a final check of compliance and are not incorporated into decision making.	Environmental justice is the primary vehicle for addressing equity in transportation. Environmental justice analysis is often conducted for compliance with regulations or as a part of NEPA requirements, but federal guidance has begun to assert that environmental justice should have a place in the planning process.	• Environmental justice may be treated as a check for environmental review and not incorporated into planning. • MPOs that include equity into their long-range plan development conduct additional analysis outside of environmental justice analysis.	Environmental justice may not be the most appropriate way to incorporate equity into planning, however, it should not simply serve as an independent check and environmental justice analysis should be leveraged in the planning process.	Incorporate equity as one of multiple factors in selecting program of projects for long-range planning. Use environmental justice analysis to inform planning for equity.	• Incorporates performance in equity over time into future planning. • Considers equity as one of multiple planning priorities. • Continues to address environmental justice regulations and concerns.
Equity is not often established as planning goal.	Only some agencies incorporate equity within their vision or as a policy objective and establish a formal commitment to use equity in planning and decision making. Often equity is not considered at discrete stages in the planning process and is evaluated outside the context of other planning criteria as a check for compliance with environmental justice requirements.	• Some MPOs have equity as a planning priority. • MPOs that have performance-based planning have performance measures used to evaluate projects or investment scenarios. Of the MPOs studied, those that had equity as a planning priority and also implemented performance-based planning had equity-related performance measures.	Performance-based frameworks help to promote the application of equity evaluations in decision making when equity is a goal. Considering equity along with other priorities allows decisions to be influenced by equity concerns.	Establish equity as a planning goal within a performance-based planning framework. Consider equity among multiple planning priorities.	• Considers equity as one of multiple planning priorities.

Gaps	Background	Case Study and Methods Analysis Findings	Conclusions	Recommendations	Values of Equitable Transportation Planning
Performance measures for equity are difficult to define.	Measuring outcomes like equity present issues including data availability, causal linkage, and subjective valuation. In part due to measurement difficulties, equity and other social measures are lacking in sustainability rating systems. Even environmental justice evaluations have limitations in analyzing equity.	• MPOs rely on environmental justice-based methods to measure equity, which have consequential limitations. • Environmental justice analysis is not equipped for cumulative impacts and MPOs evaluating equity of such impacts have expanded their measurement of equity past environmental justice.	Without quality measures, equity may not be included in performance management practices and will therefore not be considered in decision making. Sufficient measures to assess equity for long-range planning must be developed to evaluate cumulative impacts and address current analysis limitations.	Use improved equity evaluation methods, such as those proposed in this research, to inform planning for equity within a performance management framework.	• Continues to address environmental justice regulations and concerns. • Incorporates performance in equity over time into future planning. • Identifies gaps in equity outcomes and minimum level of performance.
Procedures to promote equity in transportation planning do not connect to equity outcomes.	At a minimum, all transportation agencies consider equity in planning through public outreach practices. Procedural efforts such as this support equality of opportunity but do not necessarily result in equity of outcomes. Performance-based planning strives to tie outcomes more directly to the planning process, explicitly exploring improvements in procedures to affect improvements in outcomes where necessary.	• Equality of opportunity and equity of outcome are addressed separately. • It is possible to draw a link between the two by more clearly connecting policy to outcomes throughout the planning process and monitoring performance continually as is done in performance management.	Equity considerations must be incorporated into the procedural process to influence equitable outcomes. Policies must go beyond participatory planning to include public feedback and equity concerns into the development of the TIP and the LRTP to influence outcomes.	Work within a metropolitan transportation planning process that incorporates performance management and include equity considerations throughout the performance management process (performance measures, targets, analysis, prioritization, etc.).	• Incorporates performance in equity over time into future planning.

7.4 Contributions

This research contributes to the knowledge base and professional practice of transportation planning. It puts forward a construction for approaching equity in transportation planning based in theory, develops analytical methods to evaluate transportation investments for equitable outcomes, provides a set of recommendations for moving transportation planning practices towards transportation planning for equitable outcomes and has important policy implications.

The research bridges professional practice for addressing equity in transportation to the theories of equity. It advances a theoretical construction of equity based on literature from behavioral science, political science and economics for application in the transportation context. This construction integrates three criteria of social justice for an operational understanding of equity applicable to the case of transportation planning. The construction was used as a frame to identify gaps and limitations in literature and practice, which led to the development of the concept of Equitable Transportation Planning. Equitable Transportation Planning is put forward as a suite of critical values to advance the practice of planning for equitable transportation outcomes. Key tenets include adopting a theoretical understanding of equity and accounting for cumulative impacts, issues that have not thus far been addressed.

This dissertation also empirically demonstrates the limitations of the quantitative methods most frequently used to assess equity in transportation planning. Through sensitivity testing and comparative analysis of the standard methods for environmental justice analysis, the limitations of methods for evaluating equity were elucidated. To address these limitations, a methodological framework grounded in theory was proposed with procedures for evaluating equity considerations. The framework was applied and tested against standard practice to highlight its ability to address the methodological limitations of current practices. By applying the proposed method as a part of the long-range transportation planning process, it is possible to begin to evaluate cumulative impacts over time.

Additionally, this work contributes a set of recommendations to formally incorporate considerations for achieving equity outcomes into long-range transportation

planning. It puts forward procedures to support the growing incorporation of equity into transportation planning goals and the mandate for performance-based monitoring of achievement towards goals. The recommendations are based on the theoretical construction of equity for the transportation context, the values of Equitable Transportation Planning and the proposed equity evaluation process, and they synthesize the research presented in this dissertation.

Finally, this work has important policy implications. First, the evaluation has the ability to dissociate target populations from areas of concentration and secondly, there is an opportunity to apply the evaluation to different impacts. The proposed method assesses impacts on all people of a given demographic segment, providing a comprehensive view of the distribution of the impact experienced by a given population. By removing the reliance on geographical areas of high concentration, populations that do not cluster or congregate spatially may be included in the evaluation. In this way, demographic segments such as the elderly, who are of particular interest as the general population ages, can be analyzed. Additionally, as policies are created and implemented to deconcentrate poverty and address de facto segregation, the proposed method can continue to track performance outcomes for environmental justice target populations where the current methods would become ineffective.

The proposed evaluation method can also be used to assess other impacts that result from the progressive development and implementation of transportation projects and policies, such as safety and air quality. Regional performance for such performance measures can be assessed and compared to the regional demographic analysis in a manner similar to what was explained in the dissertation. In this way, multiple performance measures can be evaluated in the context of equity.

Lastly, this research provides a framework to plan and establish policy with a focus on the goal of equitable outcomes. The planning recommendations provide policy implementation guidance that shifts equity evaluation from a check applied to the selected program alternative in the policy evaluation phase of the policy process. The recommendations reposition the equity evaluation to the policy adoption phase by using equity as a performance measure for program scenario selection. Furthermore, establishing equity as a goal has the potential to influence policy formation and collecting

performance results over time may provide compelling data for policy formation and agenda setting.

7.5 Future work

The research in this dissertation can be built upon in two key areas: applying improved accessibility measures and applying procedural recommendations in practice.

One limitation of the research was in choosing and using the appropriate measure of accessibility. The work evaluates the various levels of benefit experienced by users of the transportation system; the experience could be better examined and the evaluation could be strengthened with more robust accessibility measures. Disaggregating the three levels of accessibility (low, medium, high) to create additional levels for analysis would provide richer information about the experience of the system users, especially those with lower levels of accessibility. The steady progress towards activity-based travel forecast models presents an opportunity to develop, and the likelihood that there will be, more advanced accessibility measures for long-range planning. Additionally, improved measures will be useful in addressing the difference between real and perceived accessibility, further conveying the experience of the community of transportation system users.

The second area for future work is in applying the recommended planning procedures. The procedural recommendations are based on findings from practice obtained through case studies; however, the recommendations have not been applied in practice. The methodological recommendations have be applied in a practical case study; applying the planning recommendations in a similar fashion would provide useful feedback on the extent to which the procedures support equitable transportation outcomes.

7.6 Summary

This research identified avenues to formally incorporate equity considerations within a performance-based planning framework and provided guidance to address equity in long-range transportation planning. Through literature review, case studies and comparative analysis of methods, the research identified limitations in equity evaluation

methods currently used by transportation agencies and the gaps in planning for equitable outcomes. Based on the results, a set of recommendations for equity considerations in long-range planning was developed. The recommendations outline how equity can be formally considered in long-range regional transportation planning to influence outcomes.

REFERENCES

Agyeman, J., and Evans, T. (2003). "Toward Just Sustainability in Urban Communities: Building Equity Rights with Sustainable Solutions." *The Annals of the American Academy of Political and Social Science*, 590(1), 35–53.

Amekudzi, A.A., and Dixon, K. K. (2001). "Development of an Environmental Justice Analysis Methodology for Georgia Department of Transportation's Multimodal Transportation Planning Tool." *Proceedings of the 8th Transportation Research Board Conference on Planning Applications*, Corpus Christi, TX.

Amekudzi, A., Fischer, J., Brodie, S., Ingles, A. (2012). *Leading Practices in Organizational and Systems Performance Management in State DOTs: A Literature Review*. Georgia Department of Transportation, Atlanta, GA.

Amekudzi, A., Khisty, C. J., and Khayesi, M. (2009). "Using the sustainability footprint model to assess development impacts of transportation systems." *Transportation Research Part A: Policy and Practice*, 43(4), 339–348.

Amekudzi, A., Ross, C. Smith, M. and Brodie, S. (2011). *Impact of Environmental Justice Analysis on Transportation Planning: Literature Review*. Georgia Department of Transportation, Atlanta, GA.

Amekudzi, A. A., Smith, M. K., Brodie, S. R., Fischer, J. M., and Ross, C. L. (2012). "Impact of Environmental Justice on Transportation." *Transportation Research Record: Journal of the Transportation Research Board*, 2320(1), 1-9.

American Association of State Highway and Transportation Officials. (2006). *Measuring Performance among State DOTs: Sharing good practices*.

American Society of Civil Engineers. (2009). Board Approved Definition of Sustainability. Cited from ASCE Committee of Sustainability Meeting Agenda, November 15, 2010. 1st Green Highways and Streets Conference, Denver, CO.

Atlanta Regional Commission. (n.d.). *PLAN 2040 Stakeholder Involvement Program*. http://documents.atlantaregional.com/plan2040/docs/tp_Plan_2040_Stakeholder_Involvement_Program.pdf.

Atlanta Regional Commission. (2015a). *Transportation Assessment*. http://documents.atlantaregional.com/tcc/Transportation_Assessment_04282015.pdf.

Atlanta Regional Commission. (2015b). *The Region's Plan Policy Framework*. http://theregionsplan.atlantaregional.com/assets/documents/Policy-Framework-Final-Draft.pdf.

Atlanta Regional Commission. (2014a). *PLAN 2040 RTP Appendix C-2: Supplemental Technical Analysis and Plan Performance Data*.

Atlanta Regional Commission. (2014b). *Get Informed About The Region's Plan*. http://www.atlantaregional.com/the-regional-plan/get-informed.

Atlanta Regional Commission. (2014c). *2014 Transportation Fact Book.* http://documents.atlantaregional.com/transportation/TFB_2014_v17.pdf.

Atlanta Regional Commission. (2014d). *PLAN 2040 RTP Appendix C-1: Roadway Project Needs Assessment Analysis*.

Atlanta Regional Commission. (2014e). "TIP Project Solicitations." http://www.atlantaregional.com/transportation/transportation-improvement-program/tip-project-solicitations.

Atlanta Regional Commission. (2014f). “Social Equity.” http://www.atlantaregional.com/transportation/community-engagement/social-equity.

Atlanta Regional Commission. (2014g). “Public Engagement.” http://www.atlantaregional.com/about-us/public-involvement.

Atlanta Regional Commission. (2013). *Decision-Making Framework for PLAN 2040 RTP/TIP Update in 2014*. http://documents.atlantaregional.com/taqc/2013/Apr11/04-11-13_TAQC_Issue_Summary_and_Resolution_-_Decision-Making_Framework.pdf.

Atlanta Regional Commission. (2012). *The Atlanta Region*. http://documents.atlantaregional.com/GISdocs/ARC_Regions_Map_11x17_Dec12.pdf.

Atlanta Regional Commission. (2011a). *PLAN 2040 Framework*. http://documents.atlantaregional.com/plan2040/docs/lu_plan2040_framework_0711.pdf.

Atlanta Regional Commission. (2011b). *Updating Project Evaluation for MAP21: the Atlanta Regional Commission*. http://www.trbperformance.org/book/export/html/671.

ARC. 2006. *Environmental Justice Planning: A Fact Sheet Prepared by the Atlanta Regional Commission*. www.atlantaregional.com/File%20Library/Transportation/Transportation%20Plans/tp_e6_ej_factsheet_2007.pdf.

Bills, T. S., Sall, E. a., and Walker, J. L. (2012). "Activity-Based Travel Models and Transportation Equity Analysis." *Transportation Research Record: Journal of the Transportation Research Board*, 2320(1), 18–27.

Bohon, S., Stamps, K. and Atiles, J. (2008). "Transportation and Migrant Adjustment in Georgia." *Population Research and Policy Review*, 27, 273-291.

Boston Region Metropolitan Planning Organization. (2015). *Charting Progress to 2040 – Chapter 7*. http://www.ctps.org/Drupal/data/pdf/plans/lrtp/charting/2040_LRTP_Chapter7.pdf.

Boston Region Metropolitan Planning Organization. (n.d.). "Charting Progress to 2040." http://www.ctps.org/Drupal/charting_2040.

Boston Region Metropolitan Planning Organization. (2015a). *Charting Progress to 2040 – Chapter 2*. http://www.ctps.org/Drupal/data/pdf/plans/lrtp/charting/2040_LRTP_Chapter2.pdf.

Boston Region Metropolitan Planning Organization. (2015b). *Charting Progress to 2040 – Chapter 7*. http://www.ctps.org/Drupal/data/pdf/plans/lrtp/charting/2040_LRTP_Chapter7.pdf.

Boston Region Metropolitan Planning Organization. (2015c). *Charting Progress to 2040 – Chapter 6*. http://www.ctps.org/Drupal/data/pdf/plans/lrtp/charting/2040_LRTP_Chapter6.pdf.

Boston Region Metropolitan Planning Organization. (2014). *Central Vision Statement*. http://www.ctps.org/Drupal/data/pdf/plans/lrtp/charting/Goals_Objectives.pdf.

Boston Region Metropolitan Planning Organization. (2011). *Paths to a Sustainable Region*. http://www.ctps.org/Drupal/lrtp_paths.

Boston, T. and Boston, L. 2007. *Beyond Race and Poverty: A Multi-Dimensional Approach to Measuring Environmental Justice*. Atlanta Regional Commission, Atlanta, GA.

Bremmer, D., Cotton, K. C., and Hamilton, B. (2005). "Emerging Performance Measurement Responses to Changing Political Pressures at State Departments of Transportation: Practitioners' Perspective." *Transportation Research Record: Journal of the Transportation Research Board*, 1924, 175-183.

Brodie, S. Ingles, A., Coleville, Z., Amekudzi, A., Peters, B., and Sisiopikou, V. (2013). "A Review of Sustainability Rating Systems for Transportation and Neighborhood-level Development." *Proceedings from Green Streets, Highways & Development 2013: Advancing the Practice*. T&DI ASCE, Austin, TX.

California Department of Transportation. (2015). "Mission, Vision, Goals, Values." http://www.dot.ca.gov/hq/paffairs/about/mission.htm.

Cambridge Systematics. (2002). *Technical Methods to Support Analysis of Environmental Justice Issues*, Vol. 36. Washington, D.C.

Cambridge Systematics/High Street Consulting. (2010). *NCHRP Report 660: Transportation Performance Management: Insight from Practitioners*. National Cooperative Highway Research Program, Transportation Research Board of the National Academies, Washington, D.C.

Campbell, S. (1996). "Green Cities, Growing Cities, Just Cities?: Urban Planning and the Contradictions of Sustainable Development." *Journal of the American Planning Association*, 62(3), 296-312.

Chakraborty, J. (2006). "Evaluating the Environmental Justice Impacts of Transportation Improvement Projects in the US." *Transportation Research Part D-Transport and Environment*, 11, 315-323.

Code of Federal Regulations (CFR). (2012). "Cumulative Impacts." 40 C.F.R. pt 5. http://www.gpo.gov/fdsys/pkg/CFR-2012-title40-vol34/pdf/CFR-2012-title40-vol34-part1508.pdf.

Coleman, Jules L. (1980). "Efficiency, Utility, and Wealth Maximization." *Yale Law School Faculty Scholarship Series*. http://digitalcommons.law.yale.edu/fss_papers/4202.

Council on Environmental Quality. (1997). *Environmental Justice Guidance under the National Environmental Policy Act*. Executive Office of the President, Washington, DC.

Dong, X., Ben-Akiva, M. E., Bowman, J. L., and Walker, J. L. (2006). "Moving from trip-based to activity-based measures of accessibility." *Transportation Research Part A: Policy and Practice*, 40(2), 163–180.

Duthie, J., Cervenka, K. and Waller, S. (2007). "Environmental Justice Analysis - Challenges for Metropolitan Transportation Planning." *Transportation Research Record: Journal of the Transportation Research Board*, 2013, 8-12.

Environmental Protection Agency. (n.d.). "Environmental Justice." www.epa.gov/environmentaljustice.

European Commission. (2013). "Glossary: At-risk-of-poverty rate." http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:At-risk-of-poverty_rate.

Federal Highway Administration. (n.d.a). "Environmental Justice." www.fhwa.dot.gov.gov/ENVIRONMENT/EJ2.HTM.

Federal Highway Administration. (n.d.b). "Environmental Review Toolkit: Questions and Answers Regarding the Consideration of Indirect and Cumulative Impacts in the NEPA Process." https://www.environment.fhwa.dot.gov/projdev/qaimpact.asp.

Federal Highway Administration. (2015a). *Environmental Justice Reference Guide*. https://www.fhwa.dot.gov/environment/environmental_justice/resources/reference_guide_2015/.

Federal Highway Administration. (2015b). "Transportation Performance Management." http://www.fhwa.dot.gov/tpm/.

Federal Highway Administration. (2014). *Model Long-Range Transportation Plans: A Guide for Incorporating Performance-Based Planning*. http://www.fhwa.dot.gov/planning/performance_based_planning/mlrtp_guidebook/fhwahep14046.pdf.

FHWA. (2013). "Performance-based Planning – Metropolitan Transportation Commission." http://www.fhwa.dot.gov/planning/performance_based_planning/case_studies/san_francisco/.

Federal Highway Administration. (2007). *The Transportation Planning Process: Key Issues, A Briefing Book for Transportation Decisionmakers, Officials, and Staff*. www.planning.dot.gov/documents/BriefingBook/bbook_07.pdf.

Forkenbrock, D., and Sheely, J. (2004). *Effective Methods for Environmental Justice Assessment: NCHRP Report 532.* Transportation Research Board of the National Academies, Washington, D.C. www.onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_532.pdf.

Geurs, K. T., and van Wee, B. (2004). "Accessibility evaluation of land-use and transport strategies: review and research directions." *Journal of Transport Geography*, 12(2), 127–140.

Geurs, K., Zondag, B., de Jong, G., and de Bok, M. (2010). "Accessibility Appraisal of Land-Use/Transport Policy Strategies: More than Just Adding Up Travel-Time Savings." *Transportation Research Part D: Transport and Environment*, 15(7), 382–393.

Golub, A., and Martens, K. (2014). "Using principles of justice to assess the modal equity of regional transportation plans." *Journal of Transport Geography,* 41, 10–20.

Halden, D., Jones, P., and Wixey, S. (2005). *Measuring Accessibility as Experienced by Different Socially Disadvantaged Groups*. Engineering and Physical Sciences Research Council, Swindon, UK.

Hartell, A. (2007). "Methodological Challenges of Environmental Justice Assessments for Transportation Projects." *Transportation Research Record: Journal of the Transportation Research Board*, 2013, 21-29.

Hendren, P. G., and Meyer, M. D. (2006). *Non-Traditional Performance Measures. NCHRP 8-36, Task 53 (02).* National Cooperative Highway Research Program, Transportation Research Board of the National Academies, Chevy Chase, MD.

Iacono, M., Krizek, K. J., and El-Geneidy, A. (2010). "Measuring non-motorized accessibility: issues, alternatives, and execution." *Journal of Transport Geography*, 18(1), 133–140.

Jeon, C., Amekudzi, A. and Guensler, R. (2010). "Evaluating Plan Alternatives for Transportation System Sustainability: Atlanta Metropolitan Region." *International Journal of Sustainable Transportation*, 4(4), 227–247.

Jerome, A., and Donahue, J. (2002). *What is the Best Way to Address Environmental Justice Issues?* Arizona Department of Transportation, Phoenix, AZ. www.azdot.gov/TPD/ATRC/publications/project_reports/PDF/AZ506.pdf.

Johnson, B. J., and White, S. S. (2010). "Promoting Sustainability through Transportation Infrastructure? Innovation and Inertia in the Kansas City Metropolitan Area." *Journal of Urban Planning and Development*, 136(4), 303–313.

Johnson, D. (2015). Metropolitan Transportation Commission staff interviews.

Kane, A. (2010). "Performance Measurement/Management and Benchmarking: How to Ensure Data Reliability." Presentation given by the Director of Engineering and Technical Services, American Association of State Highway and Transportation Officials (AAHSTO) to the Association of Government Accountants, Baltimore, MD.

Karner, A., and Niemeier, D. (2013). "Civil Rights Guidance and Equity Analysis Methods for Regional Transportation Plans: A Critical Review of Literature and Practice." *Journal of Transport Geography*, 33, 126–134.

Kawabata, M. and Shen, Q. (2007). "Commuting Inequity between Cars and Public Transit: The Case of San Francisco Bay Area, 1990-2000." *Urban Studies*, 44, 1759-1780.

Khisty, C. J. (1996). "Operationalizing Concepts of Equity for Public Project Investments." *Transportation Research Record*, 1559, 94–99.

Kirkey, K. (2015). Metropolitan Transportation Commission staff interviews.

Kirwan Institute for the Study of Race and Ethnicity. (2007). *Communities of Opportunity – A Framework for a Most Equitable and Sustainable Future for All*. http://www.racialequitytools.org/resourcefiles/powell1.pdf.

Klancher, W. (2015). National Capital Region Transportation Planning Board staff interviews.

Kwan, M.-P., and Weber, J. (2003). "Individual Accessibility Revisited: Implications for Geographical Analysis in the Twenty-first Century." *Geographical Analysis*, 35(4), 341–353.

Lamont, J. (1996). "Distributive Justice." Stanford University, Palo Alto, CA. http://plato.stanford.edu/entries/justice-distributive/.

Litman, T. (2011). *Evaluating Accessibility for Transportation Planning*. http://www.vtpi.org/access.pdf.

Maantay, J. (2002). "Mapping Environmental Injustices: Pitfalls and Potential of Geographic Information Systems in Assessing Environmental Health and Equity." *Environmental Health Perspectives*, 110(supplement 2), 161-171.

Manaugh, K., Badami, M., and El-Geneidy, A. (2015). "Integrating Social Equity into Urban Transportation Planning: A Critical Evaluation of Equity Objectives and Measures in Transportation Plans in North America." *Transport Policy*, (37), 167–176.

Martens, K., Golub, A., and Robinson, G. (2012). "A justice-theoretic approach to the distribution of transportation benefits: Implications for transportation planning practice in the United States." *Transportation Research Part A: Policy and Practice*, 46(4), 684–695.

Mcgahan, A. (2015). Boston Region Metropolitan Planning Organization staff interviews.

Merriam-Webster. (n.d.). "Egalitarianism" Def 1. Merriam-Webster Online.

Merriam-Webster. (n.d.). "Libertarian". Merriam-Webster Online.

Merriam-Webster. (n.d.). “Utilitarianism”. Merriam-Webster Online.

Metropolitan Transportation Commission. (n.d.). “Planning – Snapshot Analysis.” http://www.mtc.ca.gov/planning/snapshot/.

Metropolitan Transportation Commission. (2015). “About MTC – Overview.” http://www.mtc.ca.gov/about_mtc/about.htm.

Metropolitan Transportation Commission. (2013a). *Plan Bay Area*. http://planbayarea.org/plan-bay-area/final-plan-bay-area.html.

Metropolitan Transportation Commission. (2013b). *Performance Assessment Report*. http://planbayarea.org/pdf/final_supplemental_reports/FINAL_PBA_Performance_Assessment_Report.pdf.

Metropolitan Transportation Commission. (2013c). *Equity Analysis Report.* http://planbayarea.org/pdf/final_supplemental_reports/FINAL_PBA_Equity_Analysis_Report.pdf.

Miller, D. (1992). “Distributive Justice: What the People Think.” *Ethics*, 102, 555–593.

Most, M, Sengupta, R, and Burgener, M. (2004). “Spatial Scale and Population Assignment Choices in Environmental Justice Analyses.” *The Professional Geographer*, 56, 574–586.

National Capital Region Transportation Planning Board. (n.d.). “Project Development Process.” http://www.mwcog.org/clrp/process/process.asp.

National Capital Region Transportation Planning Board. (2014a). *Regional Transportation Priorities Plan*. http://www.mwcog.org/uploads/pub-documents/vF5cWFc20140219085242.pdf.

National Capital Region Transportation Planning Board. (2014b). *Priorities Plan Assessment.*

http://www.mwcog.org/clrp/resources/2014/2014CLRPRTPPAssessmentReport.pdf.

National Capital Region Transportation Planning Board. (2014c). "Environmental Justice." http://www.mwcog.org/clrp/performance/EJ/EJintro.asp.

Neutens, T., Versichele, M., and Schwanen, T. (2010). "Arranging Place and Time: A GIS toolkit to assess person-based accessibility of urban opportunities." *Applied Geography*, 30(4), 561–575.

National Capital Region Transportation Planning Board. (2014d). "Accessibility." http://www.mwcog.org/clrp/performance/accessibility.asp.

National Capital Region Transportation Planning Board. (2014e). "Changes in Accessibility for Demographic Groups." http://www.mwcog.org/clrp/performance/EJ/EJ_accessibility.asp.

National Capital Region Transportation Planning Board. (2014f). *The African American Population and the 2010 CLRP Highway Projects*. http://www.mwcog.org/clrp/performance/EJ/images/2010/EJ%20-%20African%20American,%20Highways.pdf.

Oregon Department of Transportation (ODOT). (n.d.). "About Us." http://www.oregon.gov/odot/Pages/about_us.aspx.

Otto, B.S., and Ariaratnam, S.T. (1999). "Guidelines for developing performance measures in highway maintenance operations." *Journal of Transportation Engineering*, American Society of Civil Engineers. 125(1), 46.

Pearsall, H., and Pierce, J. (2010). "Urban sustainability and environmental justice: evaluating the linkages in public planning/policy discourse." *Local Environment*, 15(6), 569–580.

Pew Center on the States. (2011). *Measuring Transportation Investments: the Road to Results*. Pew Center on the States.

Puget Sound Regional Commission. (2012). *Equity, Opportunity, And Sustainability In The Central Puget Sound Region*. http://www.psrc.org/assets/7831/EquOppSusReport2.pdf.

Puget Sound Regional Commission. (2010a). *Appendix P – Prioritization*. http://www.psrc.org/assets/10556/T2040Update2014AppendixP.pdf.

Puget Sound Regional Commission. (2010b). *Final EIS Chapter 17 – Environmental Justice*. http://www.psrc.org/assets/3692/17-Environmental_Justice.pdf.

Puget Sound Regional Commission. (2008). *Vision 2040*. http://www.psrc.org/assets/366/7293-V2040.pdf.

Rawls, J. (1971). *A Theory of Justice*. Cambridge, MA: Belknap Press of Harvard University Press.

Roell, M. (2015). Atlanta Regional Commission staff interviews.

Sanchez, T. (2008). "Equity Analysis of Personal Transportation System Benefits." *Journal of Urban Affairs*, 20, 69-87.

Sanchez, T., Stolz, R. and Ma, J. (2004). "Inequitable Effects of Transportation Policies on Minorities." *Transportation Research Record*, 1885, 104-110.

Scammell, M., Montague, P. and Raffensperger, C. (2014). "Tools for Addressing Cumulative Impacts on Human Health and Environment." *Environmental Justice*, 7, 102-109.

Scrivner, K. (2015). Puget Sound Regional Council staff interviews.

Shay, E., Combs, T., Findley, D., Kolosna, C., Madeley, M., Salvesen, D. (2015). "Identifying Transportation Disadvantage: Mixed-Methods Analysis Combining

GIS Mapping with Qualitative Field Data." *Proceedings from 94th Annual Meeting of the Transportation Research Board*. Transportation Research Board of the National Academies, Washington, DC.

Smith, A. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations*. Edwin Cannan, ed. 1904. Library of Economics and Liberty. http://www.econlib.org/library/Smith/smWN.html/.

United States Department of Housing and Urban Development. (2015). "Data Sets: FY 2015 Income Limits." http://www.huduser.org/portal/datasets/il/il15/index.html.

United States Department of Transportation. (n.d.). "Transportation Planning Capacity Building – MPO Database." http://www.planning.dot.gov/mpo.asp.

United States Department of Transportation. (2015). "About Us - Mission." http://www.transportation.gov/mission/about-us.

United States Department of Transportation. (2012). *Department of Transportation Updated Environmental Justice Order 5610.2(a)*, Federal Register, Vol. 77, No. 91, 27534-27537.

United States Department of Transportation. (1997). *United States Department of Transportation Order on Environmental Justice*, Federal Register, Vol. 62, No. 72, 18377-18381.

United States Government Accountability Office. (1998). *Performance Measurement and Evaluation: Definitions and Relationships.* http://www.gao.gov/special.pubs/gg98026.pdf.

United States Government Accountability Office. (2010). *Statewide Transportation Planning: Opportunities Exist to Transition to Performance-based Planning and Federal Oversight.* Washington, DC.

Walster, E. (1976). “New Directions in Equity Research.” *Advances in Experimental Social Psychology*, 9, 1–42.

Young, H. P. (1994). *Equity in Theory and Practice*. Princeton, NJ: Princeton University Press.

World Commission on Environment and Development. (1987). *Our Common Future*. http://www.un-documents.net/our-common-future.pdf.

Washington State Department of Transportation. (n.d.). *Results WSDOT*. http://www.wsdot.wa.gov/publications/fulltext/secretary/WSDOTStrategicPlan.pdf.

Zhou, J. (2012). “Sustainable Transportation in the US: A Review of Proposals, Policies, and Programs since 2000.” *Frontiers of Architectural Research*, 1, 150–165.

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