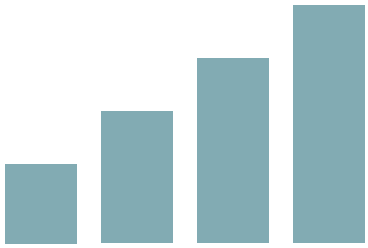
PLANNING FOR A HEALTHIER FUTURE

INCORPORATING HEALTH, EQUITY AND ENVIRONMENTAL PERFORMANCE MEASURES IN REGIONAL TRANSPORTATION PLANS

Transportation for America

TABLE OF CONTENTS

Prepared by:
CALTHORPE ANALYTICS
UD4H URBAN DESIGN 4 HEALTH
FEHR PEERS
Conveyal



About the Planning for a Healthier Future Collaborative

This report is the result of Transportation for America's (T4America) two-year Planning for a Healthier Future collaborative which included teams from the regions of Seattle, WA, Portland, OR, San Diego, CA and Nashville, TN. These four regions are working to **improve health, increase access to opportunity for vulnerable populations, protect the environment and promote economic competitiveness by developing and implementing transportation performance measures for their respective metropolitan planning organizations' (MPO) long-range transportation plans.**

This report summarizes current best practices in the development of health, equity and environmental measures that can be used to evaluate the performance of transportation investments at a regional scale. It aims to explore and test a variety of different data-driven measures that can evaluate packages of transportation investments — such as those frequently bundled together by MPOs in transportation plans.

The members of the Planning for a Healthier Future collaborative contributed to this report by providing feedback on the primary performance measures, current use of the measures and the overall report itself. The findings of this report are heavily informed by and grounded in the experience of the partners in these four metro regions (listed below). The purpose of this report is to summarize the findings and feedback of the four MPOs and serve as a helpful guide for other metro regions hoping to use performance measures and scenario planning to reach some of the same goals.

The partners in the collaborative include the Puget Sound Regional Council and Transportation Choices Coalition from the Seattle region; Metro and Upstream Public Health from the Portland region; the San Diego Association of Governments, Circulate San Diego and TransForm from the San Diego region; the Nashville Area MPO and Bicycle and Pedestrian Advisory Committee in the Nashville region; and T4America. The report also features input from the Southeast Michigan Council of Governments (the MPO in the Detroit region) and the Michigan Fitness Foundation.

Given the forthcoming rulemaking from the U.S. Department of Transportation that will require all 400-plus MPOs and 50 state departments of transportation to develop transportation performance measure frameworks, this work and the findings contained in this report are all the more important. While the new federal rule will focus on more typical engineering measures for transportation (state of good repair, traffic-related fatalities, etc.), there is tremendous interest on the part of transportation planning agencies and the public in developing more comprehensive measurement frameworks that include health, environment and social equity metrics.

This report lays out options for doing just that.

March 2016

This report and the underlying two years of research and collaboration was made possible through the generous support of the Kresge Foundation.

I: INTRODUCTION

Cities and regions around the country face important choices about how and where they want to grow, how to connect people to economic prosperity and how to use limited resources to promote healthy communities and provide a great quality of life for all of their residents.

Performance-based planning has emerged over the last decade as an effective way to evaluate the tradeoffs of land use and transportation decisions. Put simply, it allows stakeholders and decision-makers to understand how a given investment, policy, or decision "performs" across certain measures over time — providing more clarity and transparency on what state or regional transportation dollars are accomplishing.

When used effectively, performance measures can help metropolitan planning organizations (MPOs) and other regional agencies better identify policies and projects that support their goals, enable more comprehensive evaluation across multiple issue areas, demonstrate accountability and transparency, and communicate tradeoffs to stakeholders.

As we wrote in our report on performance measures (shown at right) in 2015:[1]

> Over the past 50 years, transportation agencies have focused on tracking a narrow set of goals — typically system condition, safety and sometimes traffic congestion. While these goals are important, they measure the state of the transportation system, not the impact of the system on people's lives. People want to know that transportation funds are being spent in a way that creates value, supports long-term job growth, makes their communities more attractive to business and talent and will contribute to their economic health and resilience. They are looking for a transportation system that provides not just movement but safe, reliable, affordable access to necessities like jobs, education, health care and groceries. Measuring the impact of transportation investments in a way that resonates with the public is critical going forward.

Just getting started with performance measures? This report focuses on best practices and the technical measures used by a number of regions. For a broader discussion about the "why" and the overall benefits of performance based planning, read Transportation for America's 2015 report, "Measuring What We Value."

http://t4america.org/maps-tools/performance-measures-report/

And the benefits of a better process for measuring the performance of transportation investments are clear:

> When used to engage the public and identify regional goals, performance-based decision-making can be game changing. …Performance-based decision-making allows transportation agencies to define the extent of current challenges, show what is possible at various funding levels and describe the trade-offs that might have to be considered. It can make the public a better partner to transportation agencies that

[1] Measuring What We Value: Setting Priorities and Evaluating Success in Transportation. Transportation for America, March 2015. http://t4america.org/maps-tools/performance-measures-report/

need public support to fund the system. Transportation leaders can also better understand how much they can accomplish with current funds and how to get multiple benefits from one project.

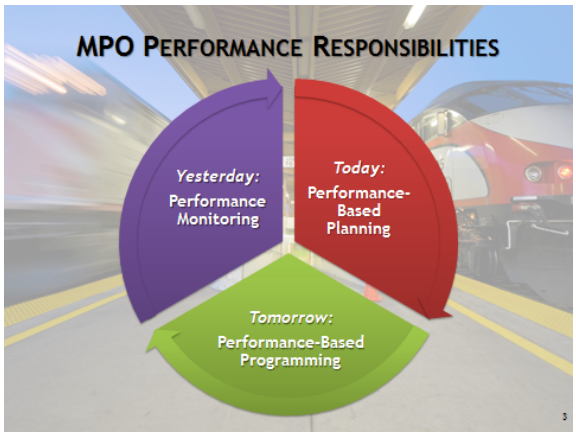
The role of regional governance

MPOs and other regional agencies play a critical role in supporting these decisions by establishing policies to best achieve desired outcomes, convening decision-makers and stakeholders, and allocating resources for transportation projects and other large projects. Because of the significant costs and impacts of infrastructure investments, it is particularly important for regional organizations to better understand the benefits and consequences of their resulting investment decisions.

Types of performance measures

There are several ways that regional agencies can incorporate performance measures to enhance their decision-making process. Three common ways measures are used in planning include:

- **Monitoring regional performance** over time to track progress towards goals and set policies
- **Evaluating proposed projects** to understand project impacts and prioritize funding
- **Comparing future scenarios** of transportation networks and/or land use at the regional level (known as **scenario planning**)



The performance measures covered in this report can and should be easily adapted and used for multiple purposes.

Transportation directly influences the economy, health and equity of a region

Previous approaches to transportation performance measures have focused on traffic speed and quality of infrastructure.[2] While these are important dimensions of transportation system performance, past experience has also shown the drawbacks of assessing transportation investments through such a narrow lens.[3] Narrowly focusing on measures of the operation of a facility (transit line, roadway, trail) fails to address the many ways that the transportation system impacts people's lives and the economy.

People's choices are influenced by their experience, which includes availability of options to access destinations, travel distances, affordability, reliability and predictability of how long a trip may take, and time spent in travel. Measures and modeling techniques that broaden the scope of performance measures to capture these important details are becoming more commonplace.

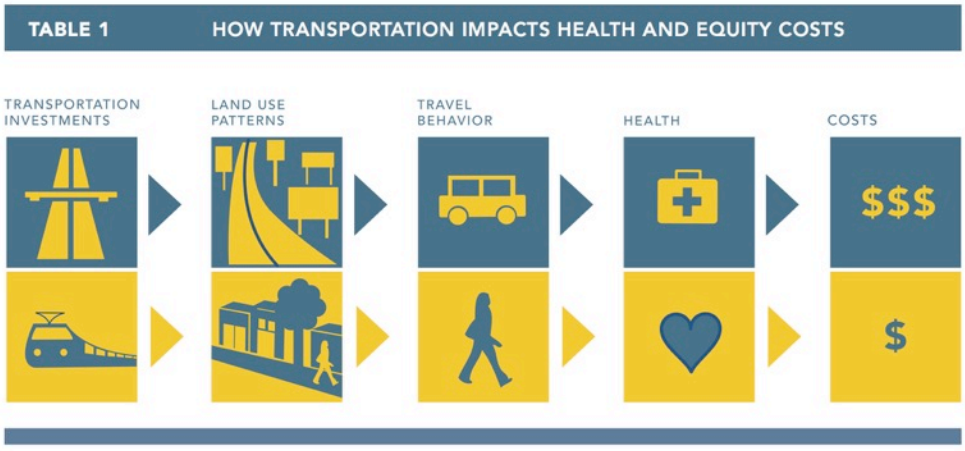
Similarly, over the last 20 years, research has increasingly pointed to the relationship between transportation and two important domains: public health and social equity.

[2] PolicyLink. (2009). Healthy, Equitable Transportation Policy. pg. 73.
[3] Ibid, page 11.

Transportation & public health

Research on the connections between transportation, land use, and health have expanded greatly in recent years. A growing body of evidence suggests that more connected land development patterns, greater density, and a walkable/bikeable street network result in an increase in physical activity for transport and recreation purposes, as well as a higher level of accessibility to community services. This increase in physical activity and access to health-related services translates into positive health related and economic outcomes, including a reduction in disease and chronic illnesses, healthier weights, and a decrease in overall health care spending.[4] Supportive environments for walking and biking can also reduce vehicle use and subsequent air pollution from cars.

Urban Design 4 Health's conceptual model below illustrates the connections and relationship between transportation investments, the built environment, travel behavior, health outcomes, and costs.



Source: Urban Design 4 Health[5]

Based on these relationships, this report lays out measures that enable MPOs and regions to understand the health impact of transportation and land use decisions within three dimensions: physical activity, traffic safety, and exposure to air pollution. Safety and air quality are not new issues to MPOs, whereas incorporating physical activity into transportation planning is. Incorporating physical activity into regional transportation planning is important because of the significant impacts active transportation has on public health outcomes, access to opportunity and local economic output. Time spent traveling by walk and bike modes is one such measure that may be used to monitor and establish goals to achieve lower chronic disease rates across the region. Measures such as chronic disease prevalence are additional measures that, despite requiring enhanced modeling tools to forecast, and a dependency on more than transportation investments alone, can be supplemental data points to inform policy decisions.

Transportation & social equity

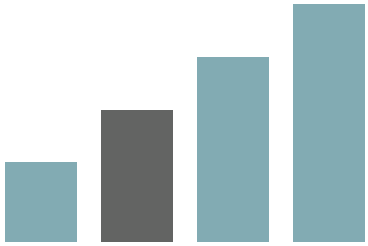
Transportation investments, both in terms of project type and distribution within a region, have strong connections to social equity. Access to jobs and other needs (known as jobs access or destinations access), household transportation and housing costs, and the aforementioned health considerations are all important equity issues directly connected to transportation and land use decisions. This report builds on existing approaches to reflecting equity considerations in regional transportation plans. These approaches fall into two categories:

- **Measure selection:** In many cases, measures can be chosen that speak to equity goals while also addressing other areas of transportation system performance. For instance, accessibility measures can reflect whether low-income or traditionally marginalized groups are able to easily get to jobs and daily needs. At the same time, accessibility offers an important basic assessment of a transportation system's

[4] Frank, L., et al. (2010). "The Hidden Health Costs of Transportation". American Public Health Association.
[5] The Hidden Health Costs of Transportation", Frank et al 2010. American Public Health Association. https://www.apha.org/~/media/files/pdf/factsheets/hidden_health_costs_transportation.ashx

effectiveness. It's worth noting that the nuances of a particular measure's formulation can be the difference between speaking directly to equity concerns or not. Where applicable, those nuances are detailed in the measures section of this report.

- **Disaggregation techniques:** The disaggregation of measures allows an agency to understand the impacts or performance of transportation investments on specific groups of people. Looking at current performance and anticipated impacts by income levels, race/ethnicity, age groups, and language communities are good starting points for understanding whether benefits are distributed to all segments of the population and whether negative impacts are disproportionately affecting certain groups of people. Looking only at performance of the system at the regional level may hide disproportionate outcomes across cities or neighborhoods. See "Recommended Measures" for a more detailed discussion of techniques for putting this approach into practice for specific measures.



II: KEY CONSIDERATIONS FOR CHOOSING MEASURES

The following key considerations are particularly useful for MPOs and regions looking to incorporate non-traditional performance such as accessibility, equitable transportation investments and health outcomes into traditional regional transportation plans.

Co-benefits and scenarios

Regional decision-making is complex, requiring consideration of impacts across many different domains (i.e. transportation, housing, economic development, etc). The variety of actors and interests in a region further complicates the factors decision-makers must consider as they compare investments. Performance measures are uniquely suited to this complex decision-making environment because they enable "apples to apples" comparisons of the impacts of decisions for varying goals and transportation priorities. However, getting the most out of performance measures requires looking across domains to identify strategies that perform well for more than one goal. This approach, which looks for benefits across themes or "co-benefits", offers a number of advantages, including:

- **Understanding tradeoffs**: Decision-makers work to ensure investments and projects align with regional goals. A co-benefits approach will surface cases in which various projects or strategies may work at cross-purposes with some goals, even if they satisfy other goals. For instance, a strategy that places housing far from major traffic corridors may reduce individual people's exposure to pollution, but may incur a cost of increased commute times, increased transportation costs as a result of increased vehicle miles traveled, and fewer opportunities for active transportation. Looking holistically at the tradeoffs of decisions helps surface these issues and develop a plan and investment program that is more likely to achieve the region's goals.

- **Supporting integrated policy-making**: Many states and regions are beginning to set policies and regulatory goals around issues such as increasing non-vehicle mode share or carbon emissions reduction. Co-benefits can help policy-makers and planners make the case for inclusion of projects and strategies that contribute to such regulatory or legislative requirements while meeting additional goals or objectives in other domains. One example of this approach in action is in California, where many regions have been able to link investments in transit-oriented development to reducing greenhouse gases, as well as additional goals around increased physical activity and public health as part of implementation of the Sustainable Communities and Climate Protection Act of 2008 (SB 375).

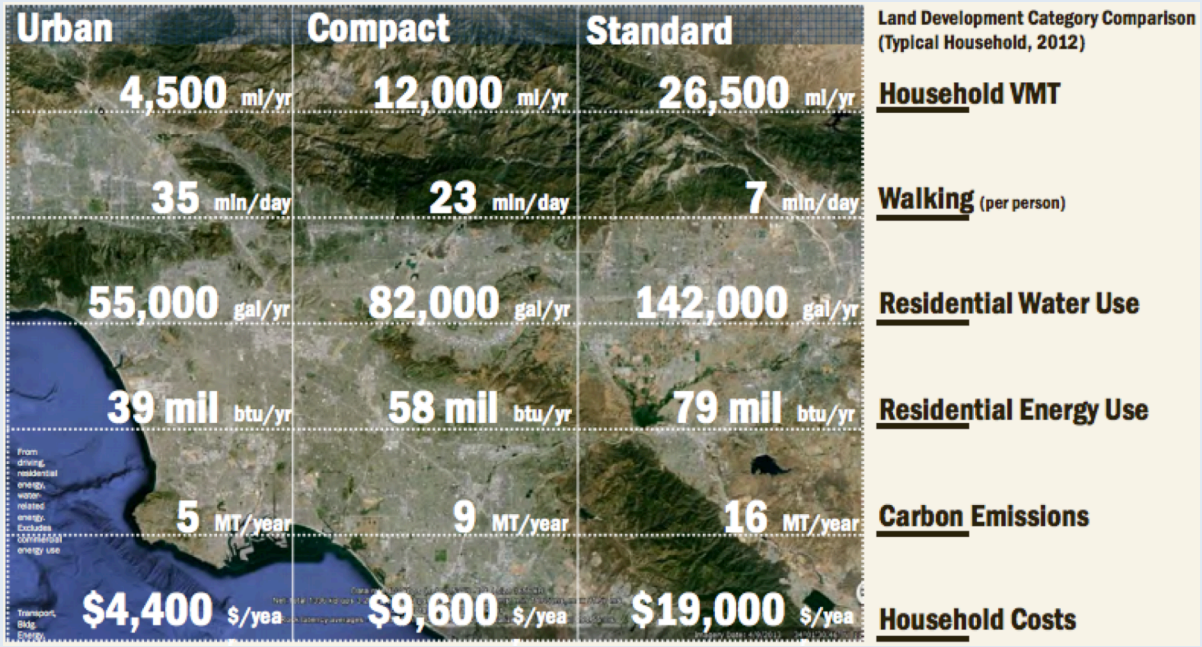
- **Coalition building**: In many cases, strategies or projects that earn high marks in areas like transit access also support other goal areas like environmental quality, social equity, or economic competitiveness. An approach focused on co-benefits, performance measures and project evaluation provides a common language for stakeholders with diverse interests to use to build coalitions and advocate for high-performing projects and strategies. This approach also enables agencies and elected officials to explain the merits of plans and projects in terms that resonate with diverse audiences.

Co-benefits analysis in SCAG's regional transportation plan

Linking development types – summarized into the urban, compact, and standard land development categories– to performance across a number of metrics enabled the Southern California Association of Governments (SCAG) to more effectively understand and communicate the co-benefits of different scenarios.[1]

The Southern California Association of Governments (SCAG) 2012-2035 Regional Transportation Plan/Sustainable Communities Strategy utilized a co-benefits analysis to assess the possible impacts of their investments across a variety of topics. This process led the agency to prioritize an investment scenario with a more dense land development pattern (represented by growth in primarily urban and compact development types) and increased investments in multimodal transportation options. For more traditional transportation measures, this strategy was beneficial as the prioritized investment scenario would reduce person delay per capita and improve freeway speeds compared to baseline conditions, while also improving access to jobs, education, and other opportunities.

Yet in addition to these transportation benefits, SCAG found that this investment strategy would lead to reduced vehicle miles traveled and greenhouse gas emissions, reduce operations and maintenance costs for municipalities, decrease average household transportation costs, and lower auto-related air pollution. The scenario would also lead to fewer health incidences such as chronic bronchitis, respiratory and cardiovascular hospitalizations, and fewer days of missed work. By monetizing these health benefits, SCAG found that the prioritized scenario would save the region over $1.5 billion per year in total costs for its health benefits alone.



Overcoming data and/or modeling constraints

As outlined above, performance measures are commonly used to 1) monitor regional performance over time, to 2) evaluate specific projects, and to 3) compare the performance of modeled scenarios. This report focuses on the latter case: measures that can be used in a scenarios-driven process to forecast different outcomes from regional transportation planning (RTP), whether it is a full regional scenario or specific projects within a given transportation RTP. However, implementation of many relevant measures for equity and health considerations currently can be hampered by a lack of significant data or modeling limitations that make forecasting difficult. In these cases there are a number of options:

- Identify proxy measures that address similar issues as the preferred measure, but with more readily available data or modeling techniques. In these cases, it is important to ensure that the proxy measure moves in similar directions as the preferred measure (e.g.: that the proxy measure performs better when one would expect the preferred measure to perform better). For example, regions that are not confident in their ability to predict bicycle and pedestrian trips with their transportation model could use the share of trips under 3 miles long as a useful proxy measure that addresses the viability of active transport trips.

- Rely on monitoring measures that provide current snapshots of regional performance. These can be used to qualitatively evaluate past investments and identify policies that increased performance, and in turn inform modeling assumptions.

Availability of data and tools

Data and modeling capacity is one of the most significant factors when an MPO and region selects its performance measures. Tools and data can vary greatly by MPO, or even within a single region. That said, there are certain levels of modeling and data that have emerged as standard practice for many regions. For instance, measures such as mode share or vehicle miles traveled can be calculated with data that is readily available by running a travel demand model. Below is a summary of the data and modeling requirements associated with the measures covered in this report (a more detailed review is provided for each measure in the next section).

A tiered approach to transportation performance measures:

Most, if not all, of the performance measures recommended in this report can be positioned along a spectrum of data/modeling sophistication and resource investment. **This means that MPOs and regions can choose measures that fit their own data and modeling capacity at any given time — including those that lack sophisticated modeling capacity.** For example, an MPO could determine a potential change in the number of homes within a half-mile of a proposed transit stop through relatively simple mapping work, while other MPOs with sophisticated models could do far more on analyzing the possible changes to emissions, accessibility, or air quality impacts.

If desired, regions can move along the gradient towards more sophisticated or nuanced measures over time. From least to most robust, the gradient of measures can be segmented into three main categories:

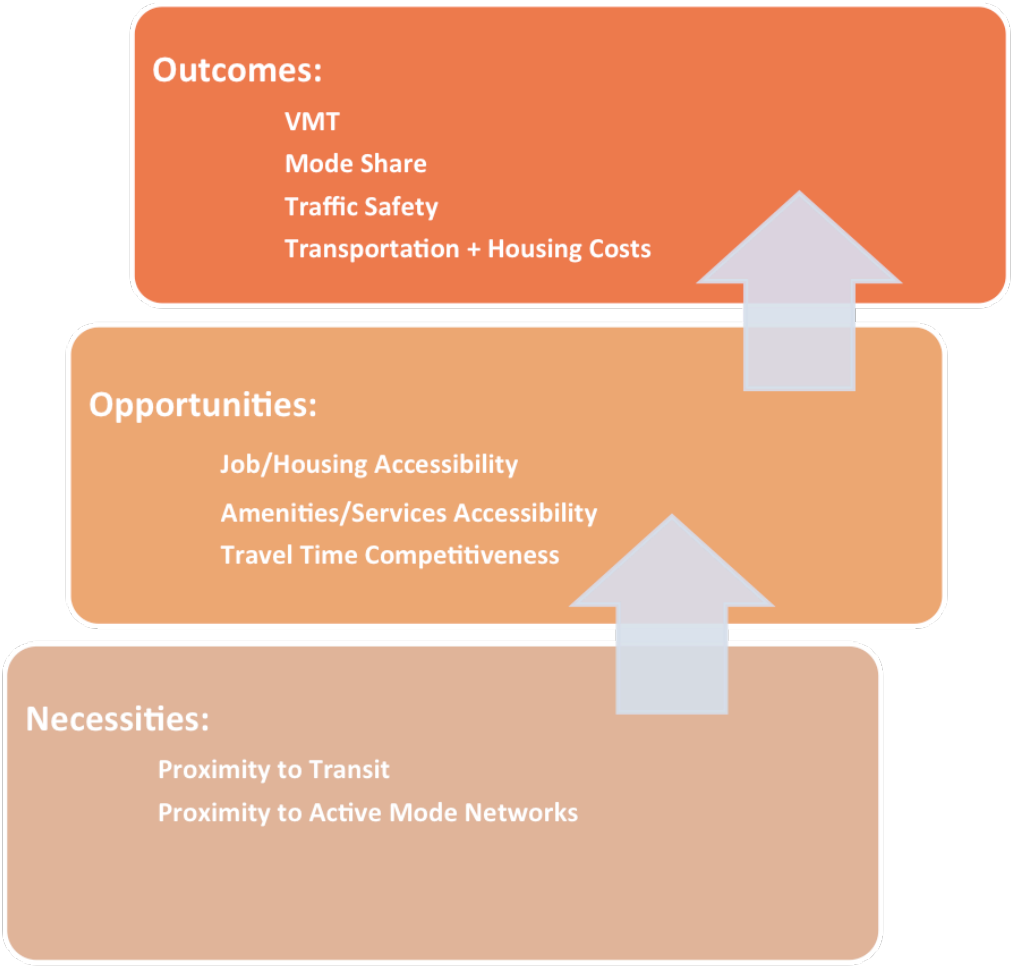
- **Necessities:** Necessities comprise the least data-intensive measures, but must correspond to a public goal. These measures generally indicate how residents will be impacted by plans and investments. Most often, these measures are proxy calculations for desired outcomes. For example, a measure of how many residents live within a half-mile of a high quality transit stop can act as a proxy for network performance in providing residents access to destinations by non-vehicle options. There are many measures outside of those recommended in this report that would also fall in this category, such as the percentage of projects that contain pedestrian/bicycle infrastructure components or the percent of total funds spent of active transportation.

- **Opportunities:** Opportunities are more specific measures for how well transportation investments perform, and require more data to model. Accessibility measures, for example, are a step up from simple proximity measures in that they incorporate transportation network analysis to quantify the proportion of regional population that networks can successfully connect to jobs, amenities, services, or other destinations. Similarly, travel time competitiveness by option can be measured in terms of time required or travel distance achievable by various modes to indicate the performance and viability of a multimodal system.

- **Outcomes:** Outcomes are direct measures of regional plan impacts. Measures in this category may be the most sophisticated in terms of required data inputs and modeling capacity. Examples include calculations of region-wide vehicle miles travelled and vehicle miles traveled per capita, collision-related deaths and injuries, and greenhouse gas emissions.

The graphic below plots some of the recommended measures featured later in this report into this tiered gradient, and further discussion of this approach is included in the measures discussion itself.

Graphic: A tiered approach to transportation performance measures[6]



Gradient of performance measures on the basis of data/modeling sophistication

[6] Graphic created by Fehr & Peers.

Reporting categories

How measures are reported can significantly clarify or obscure the insight the measure is intended to provide. Common reporting categories include:

- Per capita or per household averages
- Percent of total
- Regional average
- Subgroup comparison
- Summing to a smaller geography

The ideal reporting category for a measure may depend on the scale of analysis. For example, whereas for a corridor-level analysis it may be useful to report the increase in the number of bicycle trips following the introduction of a bicycle lane, at the regional scale, it is likely more impactful to report the mode shift as a percentage change from the base year.

Transportation, land use, and displacement

One of the most common issues to address in equity-performance plans is whether the investments within an RTP are likely to have disproportionate impacts on traditionally underserved populations. For example, would improved access to core services and availability of multiple options result in increases in property values and rents that displace current residents and businesses? What would the impacts be of an interstate ramp versus a pedestrian-oriented project? Or what might happen to an underserved community if no transportation investments were made? Transportation oriented development, high capacity and frequent transit, and improved walking and biking are in high demand and are desirable outcomes, but the impacts of these changes should be measured in order to develop programs to minimize impacts on vulnerable populations.

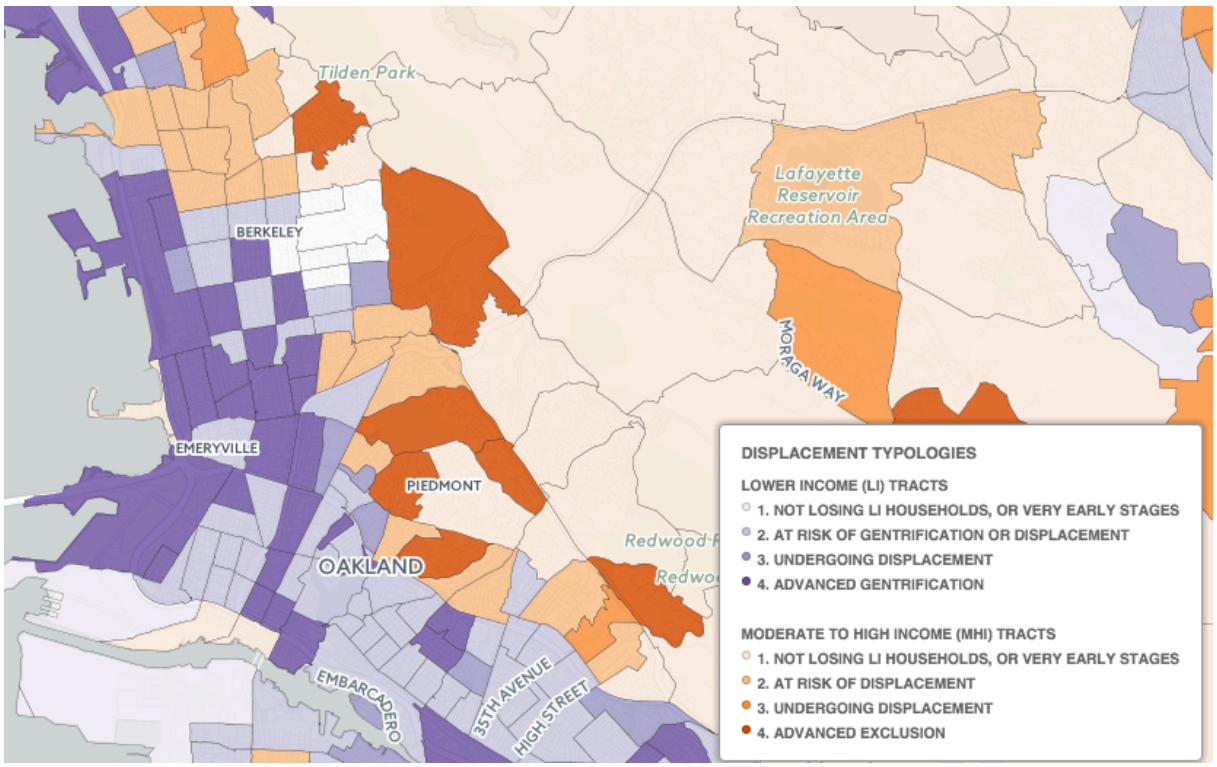
Today, measuring potential displacement focuses on identifying areas where land values and commercial and residential rents are likely to increase as a result of transportation investments, and comparing those areas with spatial data on income, number of renters, and commercial tax returns. Areas where increases in land values and rents are expected that overlap with high proportions of low-income, renter households and small businesses with relatively small sales tax returns can be considered at risk of displacement. Once identified, neighborhoods matching the metrics can be targeted with programs to counteract displacement of residents and local businesses. While this process of identifying at-risk neighborhoods is important for booming markets where displacement is an important concern, it can also be a useful process for regions with slower housing markets as a way to ensure transit investments are serving those most dependent on its service.

Displacement risk is not as robust a measure as the primary set of performance measures addressed in this report because it is difficult to quantify and model. Understanding and quantifying the impact of transportation and land use decisions on displacement is an important area for continued research.

Graphic: Assessing displacement vulnerability

The Urban Displacement Project, an initiative led by faculty at UC Berkeley in collaboration with Metropolitan Transportation Commission (MTC), local organizations, and the state's Air Resources Board, is an example of this process in action.

They recently analyzed the relationship between transit investments and neighborhood change in the Bay Area to map the region by levels of risk for displacement or gentrification. This work coincides with MTC's efforts to integrate a displacement performance measure into their planning process.



Source: Zuk, M., & Chapple, K. (2015). Urban Displacement Project. http://www.urbandisplacement.org/map

Economic benefits

Connecting large investments like transportation projects or development decisions to economic benefits, whether in public costs or household savings, is a key goal of many regions. Some measures that demonstrate health and social equity benefits lend themselves well to this, including:

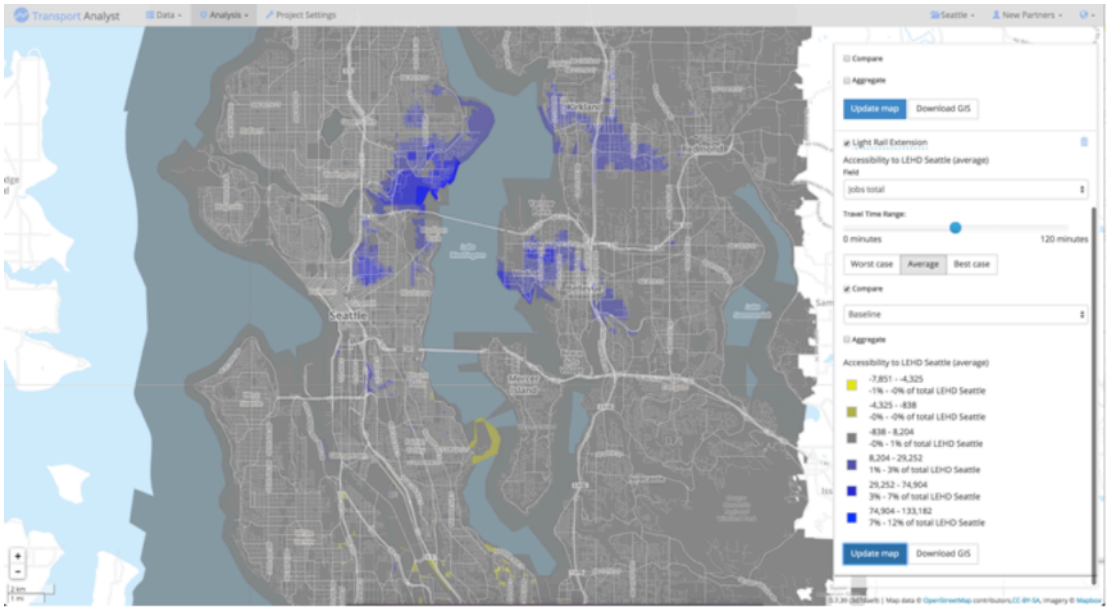
- **Transportation and household costs** can either speak to the total costs of transportation and partial costs of housing in future scenarios, or they can be calculated as average per-household savings by comparing existing conditions to future scenarios.

- **Jobs access** reflects how well workers in a region can access jobs, a key issue for many economic development initiatives. Access can be coupled with **Travel time competitiveness** (travel time for single-occupancy vehicles, high-occupancy vehicles, transit, walking and bicycling) to demonstrate economic benefits to a region by calculating the time gained or lost by workers during commute hours. The graphic below shows the use of Conveyal's Transport Analyst software to highlight the changes in access in Seattle attributable to a light rail extension project, as compared to a baseline scenario.

- **Prevalence of chronic diseases and conditions**, which can be calculated for a given scenario. Determine what the total cost would be to treat these chronic diseases and conditions and compare those costs across scenarios. Total treatment cost in each scenario can then be compared to existing conditions to determine avoided health care costs per scenario.

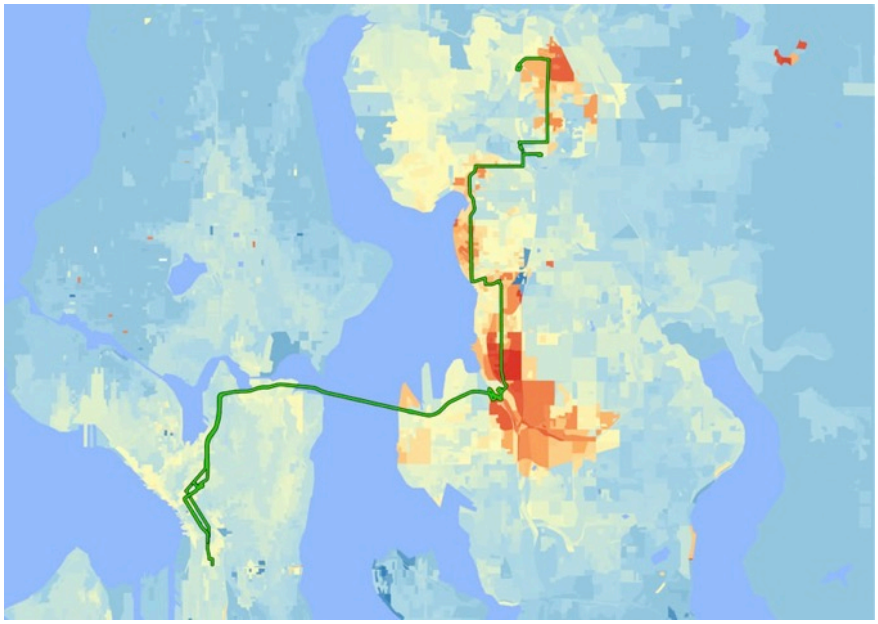
Regions can also consider building specific cost/benefit models to look more holistically at the impacts of projects or scenarios, as has been done by the Puget Sound Regional Council (PSRC) in the Seattle region.[7]

Graphic: Comparing changes in access to jobs in Seattle with Conveyal's Transport Analyst software

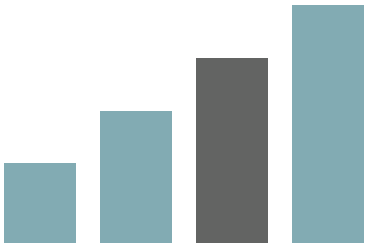


Conveyal's Transport Analyst software shows the changes in accessibility in Seattle attributable to a light rail extension project, as compared to a baseline scenario. [8]

Graphic: Improvements in access to jobs from bus service changes in Seattle[9]



[7] See PSRC. (2010). Benefit-Cost Analysis: General Methods and Approach. http://www.psrc.org/assets/2127/BCA_Methods_Report_Mar2010update.pdf?processed=true.
[8] Conveyal. (2015). Project in the Seattle Area.
[9] Conveyal. (2015). Transportation - Land Use Analysis Webpage. http://conveyal.com/img/projects/analyst-job-access.jpg



III: RECOMMENDED MEASURES

The following measures are recommended for MPOs and regions throughout the country to consider in their planning and investment programs to provide for a strong economy, healthier population, and an equitable community for all. These were developed through a process that involved a review of current state of practice in the field, interviews and discussion with five metropolitan regions (Seattle, Portland, OR, San Diego, Nashville, and Detroit), and consideration of data and modeling techniques commonly available in the U.S. These recommended measures are not intended to replace existing performance measures that cover other topics and goals; rather, they can serve as supplemental measures that offer insight into health and social equity issues within transportation plans and regional visions.

These measures are not conclusive. Every region has unique goals, needs, and data considerations that should inform measure selection. These measures are offered as a framework for connecting transportation planning to equity and health issues that is informed by both research and practice throughout the US.

How to use this section

This section organizes the recommended measures into **eight** categories, which are:

1. Environmental protection
2. Personal household costs
3. Vehicle miles traveled
4. Transportation options
5. Access to opportunities
6. Safety
7. Individual health
8. Air pollution

For each category, there are two types of measures**: primary measures**, which are recommended as the principal measures for that category, and **additional measures**, which can be used alongside primary measures to provide a fuller analysis for certain issues. In general, "primary measures" are recommended to be used by MPOs, because they best reflect the outcomes of policies or investments, or because they more fully capture the nuances of an issue that may guide policy decisions. The "primary measures" also work synergistically together to create a cohesive picture of how policies perform across various domains. However, it is important to recognize that these measures are not necessarily "superior" to the "additional measures" covered in this report or elsewhere. Instead, they should be thought of as a starting point in an MPO's process of choosing measures for a given category.

While only the "primary measures" — and guidance on their usage — are explained in detail in the two-page summaries that follow in the Appendix, we provide an description, technical requirements, and other information on the full set of both "primary" and "additional" measures in those two-page summaries.

In some cases, the "primary measures" may require data or modeling that is currently unavailable to an MPO. In other cases, the category of the "primary measures" may not be useful for a region. In either case, other measures – such as those listed in the table on the following page — should be considered.

Recommended transportation performance measures for health, equity & environment

The eight category areas are in blue below. The primary measures for each area are in bold. Alternate measures are in lighter text. More detailed information on each of these recommended measures can be found in the Appendix that follows the conclusion. Each primary measure is covered in detail there in a standalone two-page document, which also includes basic information about alternate measures for that area; if applicable.

MEASURE NAME	DEFINITION
ENVIRONMENTAL PROTECTION	
Land Consumption	**Acres of previously natural or agricultural land consumed by new development**
Vegetative Cover	Acres of land area classified as vegetation, including open areas and parks, consumed by new development
PERSONAL & HOUSEHOLD COSTS	
Transportation and Housing Costs	**Monthly or annual household spending on select housing and transportation costs**
Transportation Costs	Monthly or annual household spending on select transportation costs
VEHICLE MILES TRAVELED	
Vehicle Miles Traveled (VMT) Rate	**VMT per population (for both residential and employment areas)**
TRANSPORTATION OPTIONS	
Mode Shares	**Percent of total trips and number of trips accomplished by each mode**
Active Transportation Potential	Share of total trips that are fewer than 3 miles
Travel Time Competitiveness	Travel time for single-occupancy vehicles (SOV), high-occupancy vehicles (HOV), transit, walking and bicycling (along key corridor origin-destination (O-D) pairs) as a ratio of non-transit travel times
ACCESS TO OPPORTUNITIES	
Jobs Access	**Household/workforce access to jobs by each mode within a set amount of time**
Workforce Access	Employer/jobs access to workforce households by each mode within a set amount of time
Access to Other Opportunities	Household access to grocery stores, healthcare facilities, and parks/recreation facilities by each mode within a set amount of time
Access to Transit Services	Share of population within ½ mile of frequent transit service
Sidewalk and Bike Facility Coverage	Sidewalk and bike facility coverage as a percentage of total street lengths

Recommended transportation performance measures for health & equity (cont'd)

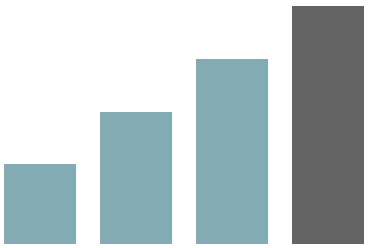
MEASURE NAME	DEFINITION
SAFETY	
Fatalities and Serious Injuries	**Reported motor vehicle crashes with pedestrians, cyclists or motorists**
INDIVIDUAL HEALTH	
Time Traveling by Walk and Bike	**Average daily time spent walking and bicycling for transportation purposes**
Disease Prevalence	**Number and/or rate of diseases such as diabetes, asthma, high blood pressure, stroke, cancer**
Healthy Body Mass Index	Percent of the population with healthy (or unhealthy) Body Mass Index (BMI)
AIR POLLUTION	
Regional Transportation-Related Air Pollutants	**Regional ambient levels of air pollution**
Exposure to Transportation-Related Air Pollution	**Percent of population within unhealthy concentrations of measured/interpolated pollutants (PM2.5)**
Transportation-Related Greenhouse Gas (GHG) Emissions	**GHG emissions (CO_2 equivalent) associated with passenger vehicles**
Building and Water Energy Greenhouse Gas (GHG) Emissions	GHG emissions associated with building energy and those associated with the transportation, treatment and distribution of water

CONCLUSION

Regions are increasingly recognizing the important role that transportation and land use play in promoting healthier and more socially equitable communities. The inclusion of measures in RTPs that reflect this significance is important both for understanding the sometimes hidden impacts of decisions as well as for prioritizing projects and investments that deliver the value in addressing these needs.

Although many regions are at the early stages in building the data and modeling sophistication necessary to more fully account for health and equity in their modeling efforts, the lesson from this report should be that there are sufficient national and commonly available resources to enable all regions to begin to incorporate equity and health into regional transportation planning. Each region should identify what issues matter the most to them and develop a road map that connects those issues to a plan for building the data and modeling capacity to evaluate them.

The measures in this report provide a good baseline for that process.



APPENDIX: SUMMARIES OF RECOMMENDED MEASURES

This appendix consists of **eleven** two-page summaries of the recommended primary performance measures.

For the eight categories of recommended measures, the primary measure (or measures) for each area is covered in detail in a standalone two-page document on the pages that follow. If applicable, basic information on alternative or additional measure(s) for that area is provided at the end of each summary.

ENVIRONMENTAL PROTECTION

Primary measure: Land Consumption

PERSONAL & HOUSEHOLD COSTS

Primary measure: Transportation and Housing Costs

VEHICLE MILES TRAVELED

Primary measure: Vehicle Miles Traveled (VMT) Rate

TRANSPORTATION OPTIONS

Primary measure: Mode Shares

ACCESS TO OPPORTUNITIES

Primary measure: Jobs Access

SAFETY

Primary measure: Fatalities and Serious Injuries

INDIVIDUAL HEALTH

Primary measures: Time Traveling by Walk and Bike
Primary measures: Disease Prevalence

AIR POLLUTION

Primary measures: Regional Transportation-Related Air Pollutants
Primary measures: Exposure to Transportation Related Air Pollution
Primary measures: Transportation-Related Greenhouse Gas (GHG) Emission

ENVIRONMENTAL PROTECTION

Primary measure: **Land Consumption**

Acres of previously natural or agricultural land consumed by new development

Why it's important

Locating new development in previously undeveloped greenfield areas consumes valuable agricultural and natural lands. Too much greenfield development, particularly large lot suburban development with limited transportation connections, contributes to longer driving distances, higher vehicle miles traveled, and lost economic benefits that accrue from agricultural and natural lands. Greenfield development that is far from transit and jobs also reduces the utility of active transportation modes like walking and biking to access these essential destinations, increasing the likelihood of obesity and associated chronic diseases.

General methodology

Land consumption can usually be derived from most sketch-based land use allocation models, either based on a projection-based forecast or through asserted land use changes, which can be based on past patterns of development and transportation network changes.

Data and technical requirements:

- Acres of land consumed from projection or asserted development as part of a transportation scenario

Evaluation level:

Project Evaluation	✓
Scenario Analysis	✓
Performance Monitoring	✓

Putting it into practice

This measure is most valuable in regions that are able to test land use scenarios alongside transportation investments. Regions with Urban Growth Boundaries (UGBs) or geographic growth barriers may opt for a variation of this measure that focuses on growth that occurs within vs. outside of UGB boundaries.

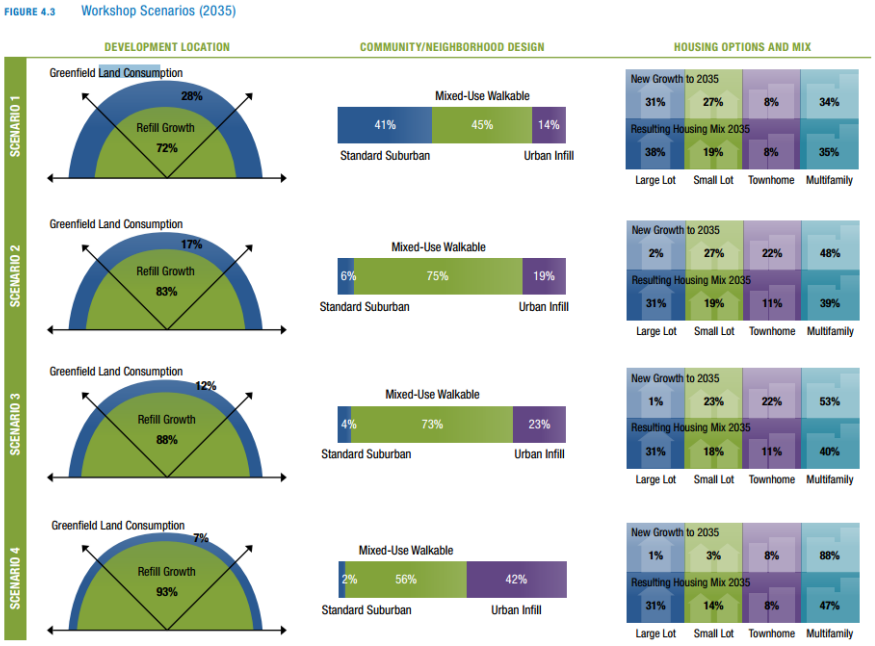
- **The Puget Sound Regional Council (PSRC)**: As an example of project evaluation, PSRC incorporates preservation of critical areas and resource lands as one of nine categories in their project prioritization process. For the 'land and water' category, projects score the most points if they improve critical areas, do not impact designated agricultural and forest lands, and use practices that improve hydrological functions to improve stormwater runoff.
- **The Nashville Area MPO:** As an example of project evaluation, the Nashville Area MPO includes an analysis of the impact to environmentally sensitive or regulated lands in its project evaluation process and offers potential mitigation strategies to project sponsors for projects that are likely to have a negative impact. This process favors projects that are located in areas of planned growth to minimize the impact that transportation infrastructure will have on sprawl and land consumption. The MPO tracks land development rates within and outside established urban growth boundaries UGBs to ensure that new growth is occurring in the intended locations.
- **The San Diego Association of Governments (SANDAG**): Land consumption is a less commonly used measure in the RTP processes for the regions in the Planning for a Healthier Future collaborative. As an example of scenario analysis, SANDAG measures the gross acres of constrained land consumed for transit and highway infrastructure as part of a technical appendix in their RTP, however it is not included as a primary performance measure for scenario comparison at the regional level, nor for project evaluation and prioritization.
- **The Southern California Association of Governments (SCAG):** In its most recent RTP/ Sustainable Community Strategy (SCS), as an example of scenario analysis, SCAG adopted land consumption as a primary performance measure for scenario comparisons. For each scenario, they first reported the percentage of new units that were located in standard suburban areas, mixed-use walkable areas, and urban infill locations, showing how each scenario compares. Ultimately, the scenario plan that was selected directs

more growth into high-quality transit areas (predominantly urban locations) than their baseline scenario. This decision for its RTP/SCS plan allows SCAG to consume 408 square miles less greenfield land than the baseline by 2040.

- **Portland Metro:** As an example of performance monitoring, Metro conducts a residential and employment buildable land inventory that informs an evaluation of the capacity of the region's UGB to accommodate a 20-year forecast for population, residential and employment growth. Even if a region has not carried out land use scenario analysis, monitoring land consumption can be a useful indicator. The inventory is prepared in consultation with cities and counties, and includes land inside the UGB that is not developed, as well as land that could be subject to infill and redevelopment based on locally adopted zoning and comprehensive plans. These local tools aim to implement the 2040 Growth Concept, which is the Portland region's long-range growth management strategy to create healthy, equitable communities and a strong economy. The inventory takes into account environmental constraints. A market-based land and transportation computer model, called MetroScope, is then used to determine how many of the new jobs and households in the seven-county area are likely to locate inside Metro's UGB.[10] This growth distribution becomes the basis for the household population and employment assumptions used in the region's travel demand model during updates to the RTP.[11]

Example

This snapshot from SCAG's 2012 RTP/SCS showing the percentage of new development located in greenfield areas for each scenario. The plan also reports the percentage of new units that were located in standard suburban areas, mixed-use walkable areas, and urban infill locations, showing how each scenario compares.



Source: SCAG. (2012). Draft 2012 RTP/SCS. http://rtpscs.scag.ca.gov/Documents/2012/draft/2012dRTP_04_SCS.pdf

Alternative measures

An alternative measure is to evaluate **vegetative cover consumed**, which focuses more specifically on lost trees/shrubs/grass and other vegetation.

Measure	Tier	Project Evaluation	Scenario Analysis	Performance Monitoring	Goal Direction	Data Requirements
Vegetative Cover	Outcomes		✓	✓	Minimize lost vegetative cover	Land cover or similar with vegetative cover consumed from

[10] More information on MetroScope can be found at: http://www.oregonmetro.gov/forecasting-models-and-model-documentation.
[11] More information on the Portland region's most recent analysis can be found at: http://www.oregonmetro.gov/sites/default/files/20151026-Final-UGR.pdf.

PERSONAL & HOUSEHOLD COSTS

Primary measure: **Relative Transportation and Housing Costs**

Monthly or annual household spending on select housing and transportation costs

Why it's important

Traditional measures of affordability have focused on housing costs alone, without taking into account the significant variability in transportation costs associated with housing type, location, and nearby land uses. Evaluating transportation and household costs together better reflects the dynamics of affordability for households.

General methodology

Forecasting housing costs with a spatial component is relatively uncommon because it is difficult to predict future rent and home ownership prices, so for scenario or forecasting purposes the components of energy and water costs, which vary by housing type and location, can be evaluated. Transportation costs include auto ownership, maintenance, and fuel costs, which vary based on vehicle miles traveled, and costs for transit usage, which vary based on the trip generation results from a travel demand model. For baseline assessment or monitoring purposes, housing costs can take into account median rent or mortgages, which are by far the largest costs associated with housing.

Data and technical requirements:

- Vehicle miles traveled per household
- Building energy/water consumption per household
- Auto operations, ownership, and maintenance costs
- Transit costs
- Housing prices

Evaluation Level:

Project Evaluation	✓
Scenario Analysis	✓
Performance Monitoring	✓

Putting it into practice

Because of the difficulty some regions have forecasting housing prices, many regions use current housing prices in conjunction with forecasted transportation costs derived from travel demand models. To get the most value out of this measure, regions should aim to look particularly at the costs for low-income households or geographies with large concentrations of low-income households, since using a regional average for housing and transportation costs can obscure the relative cost burden to households of different income levels.

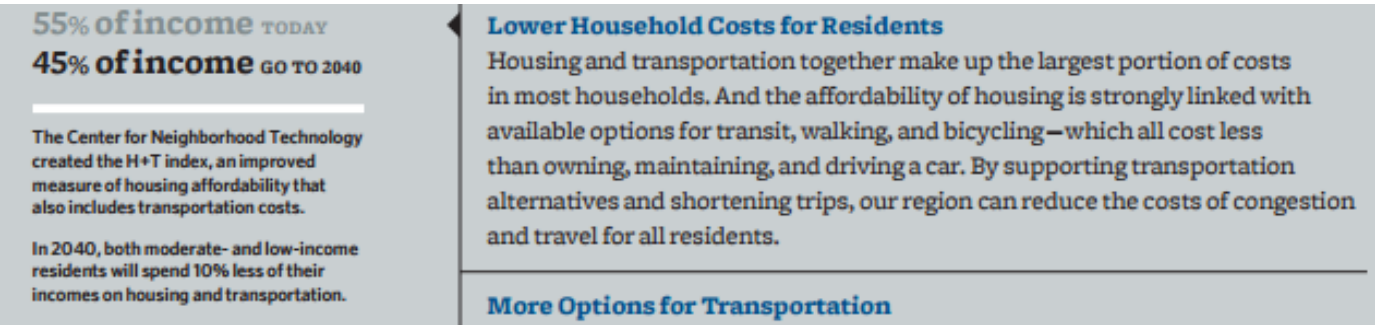
- **Metropolitan Transportation Commission (MTC):** Calculating the transportation and housing cost impacts of individual projects is not currently a standard practice for most regions. As an example of project evaluation, MTC incorporates impacts on travel costs in the project analysis process. Out-of-pocket user costs attributable to projects is criteria in the overall Benefit-Cost assessment applied to the 90 largest projects in the region.
- **Metro:** As an example of scenario analysis, Metro calculates average transportation and housing costs for households as part of its regional analysis conducted using MetroScope when preparing a 20-year forecast for population, residential and employment growth. MetroScope takes into account future rent and home ownership prices as well as household income and age-related information. Metro's RTP includes a performance target to reduce housing and transportation costs per household. An approach for measuring the impact of transportation investment scenarios on personal household costs will be developed in Metro's next RTP update to be completed in 2018.
- **SANDAG:** As an example of scenario analysis, SANDAG uses outputs from their travel demand model to calculate the percentage change in income consumed by out-of-pocket transportation expenditures related to transportation investments, reporting the changes for all identified communities of concern compared to

the general population.[12]

- **PSRC:** In PSRC's current RTP, "Transportation 2040," as an example of scenario analysis, public sector transportation costs are reviewed as a percent of regional personal income. PSRC also assesses transportation costs for specific income groups across scenarios using its benefit-cost tool. However, PSRC does not measure personal transportation costs such as fuel, insurance, car payments, etc.
- **Chicago Metropolitan Agency for Planning (CMAP):** For baseline assessment or monitoring purposes, housing costs can take into account median rent or mortgages, which are by far the largest costs associated with housing. For regions that lack the data or resources to monitor housing and transportation affordability on their own, the Center for Neighborhood Technology has developed the Housing and Transportation (H+T®) Affordability Index which incorporates several datasets to provide an affordability figures for anywhere in the US.[13] As an example of performance monitoring, CMAP utilized the Housing +Transportation Index to report current cost burdens and to project changes to housing and transportation costs as a result of their Go to 2040 plan.
- **The Nashville Area MPO**: As part of its annual indicators report Vital Signs and along with its partner the Nashville Area Chamber of Commerce, the Nashville Area MPO tracks personal and household transportation costs. (Performance monitoring.)

Example

CMAP used the Housing and Transportation (H+T®) Affordability Index to evaluate current and projected cost burdens for residents as part of their Go to 2040 plan.[14]



Additional measures

In place of measuring combined housing and transportation costs, many regions assess out-of-pocket transportation costs alone. This approach is easier as it can be derived from common transportation demand model outputs. However, as data and forecasting methodologies for housing costs become more readily available in the coming years, agencies could aim to incorporate housing costs in their assessments to better reflect the impact of growth options.

Measure	Tier	Project Evaluation	Scenario Analysis	Performance Monitoring	Goal Direction	Data Requirements
Transportation Costs	Outcomes	✓	✓	✓	Minimize transportation costs per capita	Vehicle miles traveled and transit use per household, auto ownership & maintenance cost assumptions per mile, transit cost assumptions

[12] SANDAG. (2015). San Diego Forward: The Regional Plan. Appendix N: Evaluating the Performance of the Transportation Network.
[13] Center for Neighborhood Technology. (2015). H + T Index Methods. http://htaindex.cnt.org/about/HT_Index_Methods_2013.pdf
14 Chicago Metropolitan Agency for Planning. (2014). Go to 2040. http://www.cmap.illinois.gov/documents/10180/17842/GO-TO-2040-short-plan_10-7-2010_FINAL.pdf/2840498d-96fa-43fa-9784-9c8f364b4547.

VEHICLE MILES TRAVELED

Primary measure: **Vehicle Miles Traveled (VMT) Rate**

Average or Total VMT per population (residents and employees)

Why it's important

Vehicle Miles Traveled Rate is emerging as a best practice measure for the amount of driving done in a region. It captures access, or lack thereof, to non-auto modes and proximity to destinations such as jobs and shopping. It also serves as an input to several other important measures, including transportation costs, carbon emissions, and air pollution.

General methodology:

VMT is a standard output from most validated basic or advanced, multi-modal travel models (e.g., Activity Based Models (ABM)), requiring data for household socio-economics, transit infrastructure and services, and regional distribution of housing, jobs, and other destinations. For current conditions or baseline assessment, sources such as the HUD Location Affordability Index and the EPA Smart Location Database can provide annual VMT (per capita and per household) at various census geographies.

Data and technical requirements:

- Household socio-economics
- Transit infrastructure and services
- Regional distribution of housing, jobs, and other destinations

Evaluation level:

Project Evaluation	✓
Scenario Analysis	✓
Performance Monitoring	✓

Putting it into practice

In addition to its environmental and fiscal implications, VMT rate is a basic indicator of how much people drive. It is helpful to consider alongside the related measure of mode share, which captures the generally intended goal implied by lower VMT: more travel by transit, walking, and biking. Lower VMT translates to less time spent driving, and depending on conditions, less time spent in congestion. However, lower VMT may also indicate transit dependency, without indication of transit quality. Some MPOs have linked VMT to place types that describe land use and development patterns. This can be an effective way to both understand and communicate the relationship between "what's on the ground" and driving behavior.

- **California Office of Planning and Research:** At the project level, VMT is quickly becoming the standard way to assess the environmental impacts of transportation investments. As an example of project evaluation, The California Office of Planning & Research is currently in the process of establishing VMT as the primary metric for assessing transportation impacts under the California Environmental Quality Act (CEQA). Under this proposal, projects would be assessed by whether they surpass a certain threshold of VMT, established either as by the regional average or established regional targets.[15]
- **Metro:** Measures of VMT or VMT per capita are already used for scenario comparison or regional analysis in all of the regions collaborating on this report. Metro uses per-capita projections of this measure for all scales of analysis: project evaluation, mobility corridor analyses, and for comparison of regional scenarios. For their calculation, Metro only includes trips that begin and end within the region's urban growth boundary and metropolitan planning area (MPA) boundary.
- **The Nashville Area MPO** uses VMT as a system-wide per capita measure to compare land development scenarios and to describe general travel behaviors, as an example of scenario analysis.

15 CA Office of Planning & Research. (2016). Revised Proposal on Updates to the CEQA Guidelines on Evaluation Transportation Impacts in CEQA.

- **Metro:** Annual or daily average VMT is a fairly straightforward measure to report as part of an annual performance monitoring process. Federal Highway Performance Monitoring System (HPMS) data can be used for performance monitoring for most urban areas in the country. Metro uses HPMS data for performance monitoring and reports these numbers in the transportation conformity report (in compliance with the Carbon Monoxide State Implementation Plan) and the Oregon Department of Land Conservation and Development (DLCD) monitoring report (completed every other year).

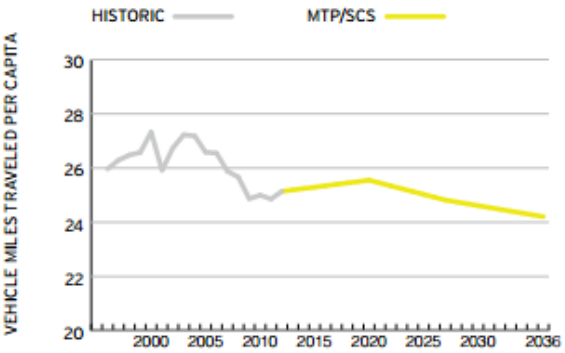
Example

The Sacramento Area Council of Governments (SACOG) reports total VMT and VMT per capita broken out for each county in the region. Reporting VMT at a per-capita level helps account for the projected population increase in the region.[16]

TABLE 5B.2
Total Vehicle Miles Traveled in SACOG Region, 2012 and MTP/SCS

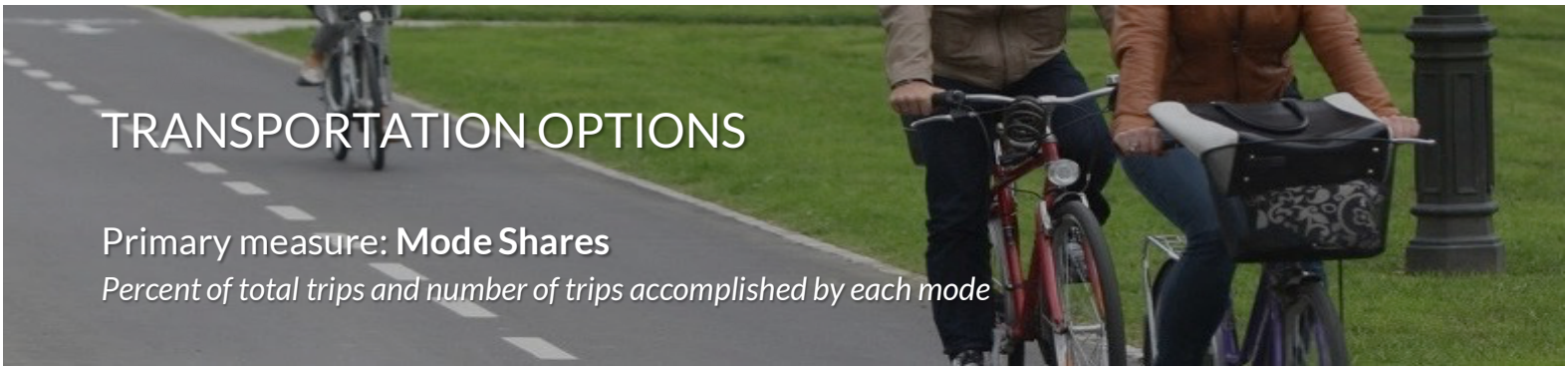
County	2008	2012	2020	2036
Total Weekday VMT on Roadways[1]				
El Dorado[2]	3,871	3,735	4,121	4,666
Placer[2]	9,790	9,894	11,360	13,762
Sacramento	34,666	33,760	37,092	43,669
Sutter	2,146	2,027	2,254	2,777
Yolo	5,807	5,862	6,442	7,431
Yuba	1,772	1,732	1,907	2,215
SACOG Region	58,051	57,010	63,176	74,520
Total VMT per Capita	26.2	25.1	25.6	24.2
Annual Average Growth Rates	**'08 to '20**	**'12 to '20**	**'20 to '36**	**'08 to '36**
VMT	-0.5%	+1.3%	+1.0%	+0.9%
Population	+0.6%	+1.1%	+1.4%	+1.2%
VMT Per Capita	-1.1%	+0.2%	-0.4%	-0.3%

FIGURE 5B.2
Weekday Vehicle Miles Traveled per Capita in the SACOG Region, Historic Trends and Projected MTP/SCS



Historic based on CPRD reports. MTP/SCS based on SACOG forecasts.

[16] Sacramento Area Council of Governments. (2016). 2016 Metropolitan Transportation Plan / Sustainable Communities Strategy. Chapter 5B. http://www.sacog.org/sites/main/files/file-attachments/chapter_5b_vehicle_miles_traveled_and_roadway_congestion_trends_and_performance.pdf



TRANSPORTATION OPTIONS

Primary measure: **Mode Shares**

Percent of total trips and number of trips accomplished by each mode

Why it's important

Mode shares reflect outcomes of land use and transportation decisions. Higher non-single occupancy vehicle mode shares result in reduced pollution from autos, health benefits from active transportation, and improved access to jobs and services for people without access to a personal vehicle. While transit, pedestrian and bicycle accessibility tools are important to understanding whether RTPs provide transportation choices, mode share measures whether provision of those choices results in more non single-occupant vehicle travel. This provides a concrete measure of whether transportation investment strategies, combined with land use decisions, are having the desired effects.

General methodology

Mode share is a standard output from most validated basic or advanced (e.g., ABM) multi-modal travel models, provided those models have active mode capability or off-model active transportation tools. For baseline or monitoring purposes, the US Census provides a number of data sets that can be used such as the Census Transportation Planning Products (CTPP) and National Household Travel Survey (NHTS).

Data and technical requirements:

From regional travel model data:

- Household socio-economics
- Transit infrastructure and services
- Regional distribution of housing, jobs, and other destinations

Evaluation level:

Project Evaluation	✓
Scenario Analysis	✓
Performance Monitoring	✓

Putting it into practice

Changes in mode share are typically measured in terms of percentage point changes, with large shifts at the regional scale represented by seemingly small numbers. For instance, a four-percentage-point change in regional biking mode share is usually a very significant increase, one that would likely be noticeable to most residents in those neighborhoods that exhibited that change. For this reason, it is often useful to show changes within sub-areas (e.g., mode share shifts within key corridors) or to report changes as raw totals (e.g., 50,000 more trips taken by bicycle). This is also a measure that, to the extent possible, benefits from evaluation specifically for low-income and other groups that might have more reliance on transit and active transport modes.

- **SANDAG:** As part of their regional plan (project evaluation level), SANDAG reports daily and peak period mode shares for the 19 most heavily traveled corridors in the region. They also report the average travel times for each mode along these corridors, permitting a travel time competitiveness measure to be calculated as well.
- **The Nashville Area MPO** relies on a non-motorized mode latent demand model to demonstrate the walking/bicycling potential for ¼ mile areas across the region based on population, employment, and land use characteristics. This model is incorporated into the project evaluation process by providing additional consideration in the evaluation for projects that provide facilities in areas with greater non-motorized demand potential.
- **METRO:** Mode share is a measure that is already widely used across the regions. Single occupancy vehicle, shared ride, transit, bicycling and walking mode shares are typically calculated for scenario comparisons at the regional level. Metro's system-wide analysis focuses on trips that begin and end inside the urban growth boundary or metropolitan planning area boundary. In addition to the regional analysis of vehicle miles traveled, Metro also calculates mode shares at sub-area levels for corridors or projects where significant investments are proposed. Metro also compares mode shares for designated mixed-use centers designated for future growth to monitor whether scenarios are meeting adopted modal targets for these areas. They also compare average

transit and auto travel times along key corridors that serve as key regional travel routes or where major projects are proposed.

Example

SANDAG reports mode share both as a regional total, and broken down to specific corridors.[17]

Table TA 3.3 – 2050 Regional Transportation Plan Mode Share in Peak Periods for Selected Screenlines

		Current (2008)		No Build (2050)		Revenue Constrained (2020)		Revenue Constrained (2035)		Revenue Constrained (2050)	
		Number	%	Number	%	Number	%	Number	%	Number	%
1	**I-5 Palomar Airport**										
	Drive Alone	62,515	76%	71,806	72%	62,102	71%	73,649	71%	76,904	69%
	Carpool	12,674	15%	17,059	17%	15,755	18%	16,731	16%	18,993	17%
	Truck	4,153	5%	9,182	9%	5,500	6%	8,224	8%	9,810	9%
	Transit	2,644	3%	1,931	2%	4,706	5%	5,031	5%	5,726	5%
	Total	81,986	100%	99,978	100%	88,063	100%	103,635	100%	111,433	100%
2	**SR 78 Vista**										
	Drive Alone	55,793	77%	70,298	75%	58,535	73%	65,055	73%	70,185	73%
	Carpool	12,592	18%	15,460	17%	15,087	19%	15,487	17%	16,945	17%
	Truck	2,151	3%	3,944	4%	2,666	3%	3,410	4%	3,754	4%
	Transit	1,755	2%	3,325	4%	3,536	5%	5,571	6%	5,975	6%
	Total	72,291	100%	93,027	100%	79,824	100%	89,523	100%	96,859	100%

Additional measures

While mode share is preferred as a direct outcome measure, in some instances, it may be difficult for regions to accurately model pedestrian, bicycle, or transit mode shares due to their current lack of representation in household travel surveys. In these instances, measures such as **active transport potential** and **travel time competiveness for transit vs. single occupancy vehicles** are also useful for understanding how modes compare in a region.

Measure	Tier	Project Evaluation	Scenario Analysis	Performance Monitoring	Goal Direction	Data Requirements
Active Transport Potential	Opportunities	✓	✓	✓	Maximize proportion of trip productions and attraction that are within 3 miles	Buffering of trip attraction destinations within 3-mile radius of household locations
Travel Time Competitiveness for Transit vs. SOV	Opportunities	✓	✓	✓	Maximize time savings per capita; Minimize transit delay; Maximize transit competitiveness	From regional travel model data: Transit network skims of costs and times including first-mile and transfers; Forecasted travel times along principal corridors for each mode

[17] Source: San Diego Association of Governments. (2011). 2050 Regional Transportation Plan. Appendix 3: Goals and Performance Measurement.

ACCESS TO OPPORTUNITIES

Primary measure: **Jobs Access**

Household/workforce access to jobs by each mode within a set amount of time

Why it's important

The ability of workers to access jobs is a measure of the economic potential of a city and its people, and measuring job access by transport mode allows comparisons between travel options and evaluation of the competitiveness of alternative modes. Higher access to jobs by multiple transportation options also leads to more potential for people to choose active transportation options that increase physical activity and positive health outcomes. Some regions are measuring and setting travel time targets for commutes to job centers, an important measure for the public and decision-makers. Relatedly, regions can look at the number of jobs accessible to the population within a maximum travel time.

General methodology

Basic data requirements are the locations of jobs and workers at a fine spatial resolution (e.g., Census blocks). For base-year studies, this is available from the Census Bureau LODES dataset in the US. Projected land use can also be supplied, for example from sketch planning tools or land use models. Additionally, transportation network data is required. OpenStreetMap is a free data source available worldwide for the street network and General Transit Feed Specification (GTFS) data is available in most cities for transit. Modified or projected network data can also be supplied. These datasets are then combined using an accessibility calculation tool (e.g., Transport Analyst from Conveyal or OpenTripPlanner Analyst).

Data and technical requirements:

- GTFS (transit) and accessibility mapping tools
- OpenStreetMap (roadway and active transport)
- US Census (LEHD for workforce/workplace)
- Traffic data (optional – for accurate drive times)

Evaluation level:

Project Evaluation	✓
Scenario Analysis	✓
Performance Monitoring	✓

Putting it into practice

As a best practice, agencies should measure job access experienced by specific groups. For example, a best practice is comparing the job access experienced by low-income residents with the regional average. Capitalizing on the equity implications of access often also requires drilling down the specific types of jobs available. The Census LODES dataset provides both employment sector (NAICS codes) as well as wage categories that can be evaluated to look at "fit" between particular groups (e.g., low income, low educational attainment, etc.) and the types of jobs accessible to those demographic groups.

- **The Southeast Michigan Council of Governments (SEMCOG):** While few regions quantitatively assess changes in employment or service access at the project level, tools and methodologies in this field are rapidly evolving. Tools such as Transport Analyst or OpenTripPlanner permit regions to evaluate the accessibility levels made possible by various projects. As an example of project evaluation, SEMCOG, in partnership with the Michigan Fitness Foundation, recently approved the *Access to Core Services* policies for its seven-county region. The policies identify what essential destinations are that should be mapped by SEMCOG and have access improved (e.g., transit, jobs, health care facilities, grocery stores, recreation opportunities, education, libraries and housing, including affordable, subsidized and assisted housing). SEMCOG has benchmarked access to these core services to understand how well the regional transportation system services the people of Southeast Michigan. These benchmarks and measures are used to set priorities and criteria for future transportation projects and decision-making and will be integrated into SEMCOG's unified planning efforts, including the RTP.
- **PSRC:** As another approach to assessing accessibility impacts, PSRC uses measures such as access to jobs, access to healthy food options, and access to parks and open space in their project evaluation process by asking project sponsors to qualitatively describe how the project improves access for residents.

- **SANDAG, METRO & PSRC:** Access to opportunities encompasses a series of measures that have been applied differently for the purpose of scenario comparisons (analyses). SANDAG and Metro both measure access to jobs for regional scenario comparison and for corridor analyses. SANDAG also has performance measures for access to healthcare facilities and access to parks and beaches. In addition to these access measures, SANDAG, PSRC, and Metro all use proximity to transit service as a measure in their regional scenario analysis. SANDAG differentiates this measure between proximity to all transit stops and to high frequency transit stops. They model both of these measures for future scenarios to calculate the percentage of the population within 15 minutes of the destinations by private vehicle and transit.

  Accessibility measures have yet to catch on as a tool for performance monitoring, however with tools becoming easier to use and more plentiful, it will become increasingly easier and cost effective to quickly assess accessibility for a variety of key destinations such as jobs, schools, healthcare facilities, parks, and open space.

Additional measures

Once a measure such as job access is being used as a performance assessment tool, it is relatively straightforward to expand the analysis to other areas of interest. For example, one might measure access to healthcare facilities, parks, or workforce (flipping the job access figure to measure how many potential employees can reach the site of a business within a particular time threshold). For regions that do not have access to GTFS data for their transit network, access to transit service can be a useful proxy measure to assess the geographic coverage of the region's transit network. In this instance, however, agencies should measure access to high-quality transit service (less than 15 minute headways). Agencies can also include measures such as sidewalk & bicycle facility coverage to monitor the extent to which the region's transportation network provides infrastructure to make biking and walking a viable alternative.

Measure	Tier	Project Evaluation	Scenario Analysis	Performance Monitoring	Goal Direction	Data Requirements
Workforce Access	Opportunities	✓	✓	✓	Maximize workforce access to workers' residences	Same as Job Access requirements
Access to Other Opportunities (& Health Related Services)	Opportunities	✓	✓	✓	Maximize access to health care, groceries, parks, schools, etc.	• Location of facilities / destinations (entrances or boundaries) • Roadway shapefile • Transit service schedule database (GTFS) and shapefile • Home and work locations
Access to Transit Service	Necessities	✓	✓	✓	Maximize share of population within ½ mile of frequent transit service	• Transit stop / station locations • Census Population • Street centerline data
Sidewalk and Bike Facility Coverage	Necessities	✓	✓	✓	Increase sidewalk and bike facility coverage	• Road file indicating presence/absence of sidewalk or bike facility • Additional information may be needed to cover off road facilities such as trails

TRAFFIC SAFETY FOR ACTIVE MODES

Primary measure: **Fatalities & Serious Injuries**

Reported motor vehicle crashes with pedestrians, cyclists or motorists

Why it's important

Locations experiencing a higher than average crash rate discourage walking and biking for transport and recreational purposes. In addition, research such as Smart Growth America's Dangerous by Design has shown certain street types like arterials can have significantly higher crash and fatality rates.[18] These areas require identification and particular attention paid to safety improvements for all users (e.g. signage, signalizations, crossing treatments, and traffic calming).

General methodology

Using police crash report data, calculate the number of injuries and fatalities (between motor vehicles / pedestrian and motor vehicle / bicyclist and motor vehicle). Often this is done per 100,000 population, though can also be reported as the number of injuries and collisions per pedestrian/bicycle mile traveled, if reliable data are available. The Pedestrian Danger Index (PDI), developed by the Surface Transportation Policy Partnership, reflects the rate of pedestrian deaths relative to the number of people who walk to work in the region.[19] Regions can also map crashes to identify high crash locations. Another variation is to measure pedestrian/bicyclist fatalities as a percentage of total traffic fatalities, which helps illuminate the often disproportionately high fatality and serious injury rates that pedestrians and bicyclists face.

Data and technical requirements:

- Police crash reporting data

Evaluation level:

Project Evaluation	✓
Scenario Analysis	✓
Performance Monitoring	✓

Putting it into practice

This measure of safety is generally used to set goals, and then monitor changes over time. Although it is currently difficult to forecast, it can be used to inform assumptions and details of modeling activities around land use assertions, transportation projects to invest in, and other activities. That said, it will likely become easier to model in coming years as data improves through the use of new technologies, research into the relationship of street and intersection types and crash rates, and other advancements.

- **All regions:** All of the regions included in this report incorporated pedestrian/bicycle crash data into their analysis of current conditions for project evaluation. **PSRC, Metro and Nashville Area MPO** each use state collision data to conduct project evaluations; however, due to modeling limitations, none forecasted this data for future impacts. Metro, however, has adopted a performance target to reduce the number of motor vehicle, bicycle and pedestrian serious injury and fatal crashes. The Nashville Area MPO places significant weight on the potential for projects to improve roadway safety including safety for pedestrians and bicyclists in the evaluation process. Projects that include safety-related improvements as the primary objective or those that improve known safety issues through roadway widening, and those that enhance safety for non-motorized users and transit customers in areas of high demand are given priority over other projects.
- **SANDAG**: SANDAG has a performance measure of annual projected number of bicycle/pedestrian injuries and fatal collisions per bicycle/pedestrian miles traveled. They project this measure for future scenarios in their regional analysis.

[18] Smart Growth America. (2014). Dangerous by Design. http://www.smartgrowthamerica.org/documents/dangerous-by-design-2014/dangerous-by-design-2014.pdf

[19] Ibid.

- **SANDAG, MTC & Metro:** To monitor performance, SANDAG measures active transport crashes as the number of bicycle/pedestrian injuries and fatal collisions per bicycle/pedestrian miles traveled. As part of their Vital Signs data portal, MTC provides maps and charts tracking fatalities from crashes in the region. Using the Statewide Integrated Traffic Records System and the National Highway Safety Administration's Fatality Analysis Reporting System, they both report crashes per year and map the crashes to illuminate collision hotspots in the region for bicyclists and pedestrians. Metro (Portland) uses state collected collision data to track fatalities and injuries from crashes in the region. Metro provides public access to this information through the web-based portal https://crashmap.oregonmetro.gov and is using the data to define a high injury network and update the region's performance targets through its current RTP update.

Example

SANDAG has separate performance measures for vehicle injury/fatal collisions and for bicycle/pedestrian injury/fatal collisions.[20]

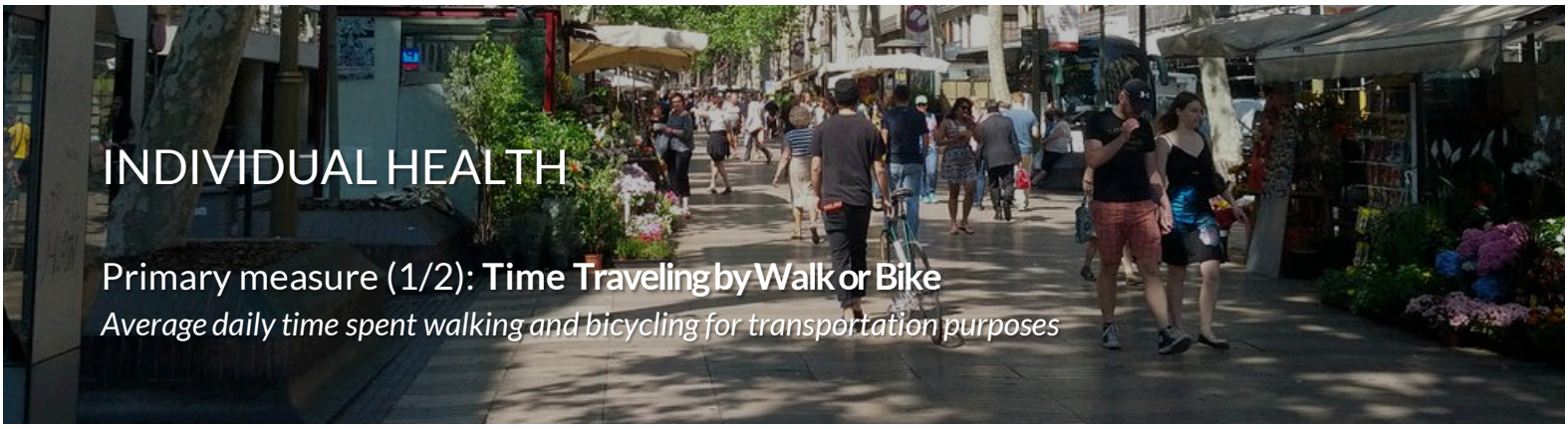
	Goals and Performance Measures	Existing (2008)	No Build (2050)	Revenue Constrained (2020)	Revenue Constrained (2035)	Revenue Constrained (2050)
	System Preservation And Safety					
1	Annual projected number of vehicle injury/fatal collisions per 1,000 persons	4.07	4.22	3.83	4.03	4.20
2	Annual projected number of bicycle/pedestrian injury/fatal collisions per 1,000 persons	0.63	0.56	1.07	1.72	2.63

Additional measures

While the primary measure for this category focuses on active transportation crashes, it is also important to evaluate the overall fatality and serious injury rate as an additional measure. Increasing overall traffic safety improves public health and can have additional benefits to active modes as well.

Measure	Tier	Project Evaluation	Scenario Analysis	Performance Monitoring	Goal Direction	Data Requirements
Fatalities and serious injuries – Overall	Necessities		✓	✓	Minimize number of fatalities and serious injuries	Police crash reporting data

[20] San Diego Association of Governments. (2011). 2050 Regional Transportation Plan. Appendix 3: Goals and Performance Measurement.



INDIVIDUAL HEALTH

Primary measure (1/2): **Time Traveling by Walk or Bike**

Average daily time spent walking and bicycling for transportation purposes

Why it's important

The amount of time spent being physically active has a strong, positive impact on health outcomes including body mass index and disease prevalence. Travel time by walking and biking is a measure of physical activity. Within the role of regional transportation agencies, it also represents a measure most salient to influence individual health outcomes.

General methodology

Use regional travel model skim files with trip distances and calculate travel times. Also, off-model tools can be created to calculate time spent in non-motorized travel.

Data and technical requirements:

- Regional travel model skims of trip times
- Off-model walk/bike mode share prediction tools such as SCAG's Active Transportation (AT) model

Evaluation level:

Project Evaluation	✓
Scenario Analysis	✓
Performance Monitoring	✓

Putting it into practice

MPOs could focus on reducing the percentage of auto trips made that are less than three miles (an average bike trip) or less than a ½-mile (an average walk trip), and shifting them to more active modes. Improving walking and bicycling conditions to transit stops and stations can also facilitate increased trips made by those modes. Active trips can be measured regionally as a proxy for levels of physical activity and can be a focus for target setting, or criteria applied to project selection. Mode share is important for putting travel times for walking and biking in context, since their length may or may not be connected to underlying inefficiencies related to poor access to transit service or vehicles.

- **Nashville Area MPO:** An MPO could prioritize funding projects that are most likely to lead to increases in walking (by especially focusing on improvements made to destinations that are ½ mile or less apart) and bicycling (focusing on destinations that are three miles or fewer apart). As an example of project evaluation, in 2012, the Nashville Area MPO conducted a study to determine the health and transportation behaviors of nearly 11,000 residents in 6,000 households. MPO staff analyzed the results to determine the socioeconomic and geographic characteristics that most correlated with poor health status: households in census tracts with higher than average rates of unemployment, poverty, residents older the age of 65 and no vehicles. As a result of this study, the MPO now prioritizes projects that increase access to active transportation opportunities target population areas and those areas that are more ready to facilitate active transportation trips because of their existing land use. Specifically, in the MPO's project evaluation and selection method for the 2040 RTP, the MPO awarded points to projects that would provide walking or bicycling infrastructure in an area with a high "latent demand" for walking and bicycling trips due to the close proximity of a variety of destinations.[21] Matching the number of latent trips with average trip durations allows the estimation of the hours of physical activity.

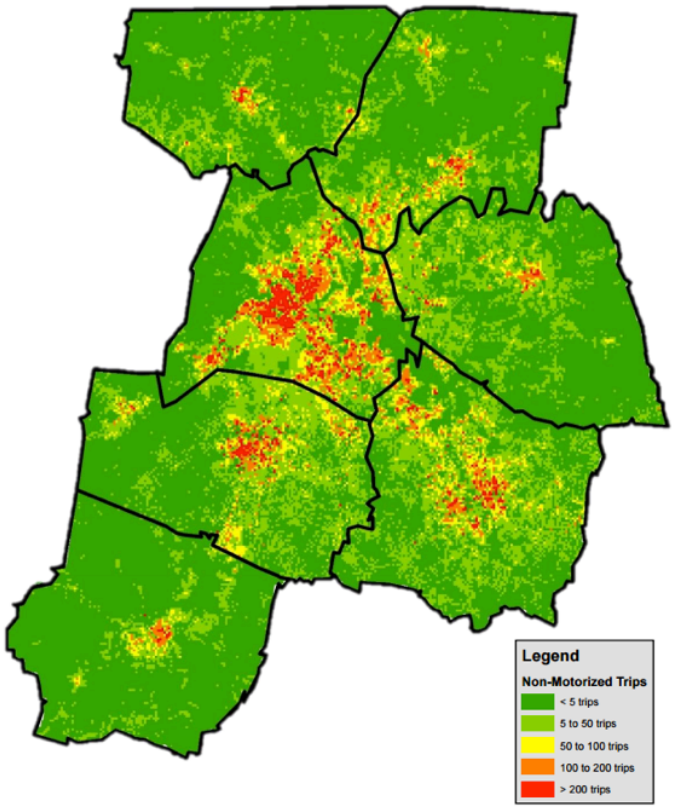
- **SANDAG:** As an example of scenario analysis, SANDAG included time traveling by active transport as performance measures in their most recent RTP, measuring both the total time engaged in transportation-related physical activity per capita and the percent of the region's population that engage in more than 20 minutes of daily transportation-related physical activity. Metro has developed a regional bicycle travel model that complements the regional travel demand mode and measures bicycle miles traveled region-wide and per person. Metro is working to develop an approach to calculate speed and minutes of bicycle travel.

[21] Source: Nashville MPO. (2015). 2014 Regional Bicycle & Pedestrian Non-Motorized Demand Physical Activity Assessment. http://www.nashvillempo.org/docs/bikeped/Non-MotorizedDemand_TechMemoDraft012715.pdf

Moving forward, they also plan to continue pedestrian model enhancements to better account for walk trips and minutes of travel on foot in the region.

Example

This map depicts the predicted intensity of non-motorized trips in 2040 from Nashville's Non-Motorized Latent Demand Model. These trips were then matched with average trip durations to estimate hours of physical activity.[22]

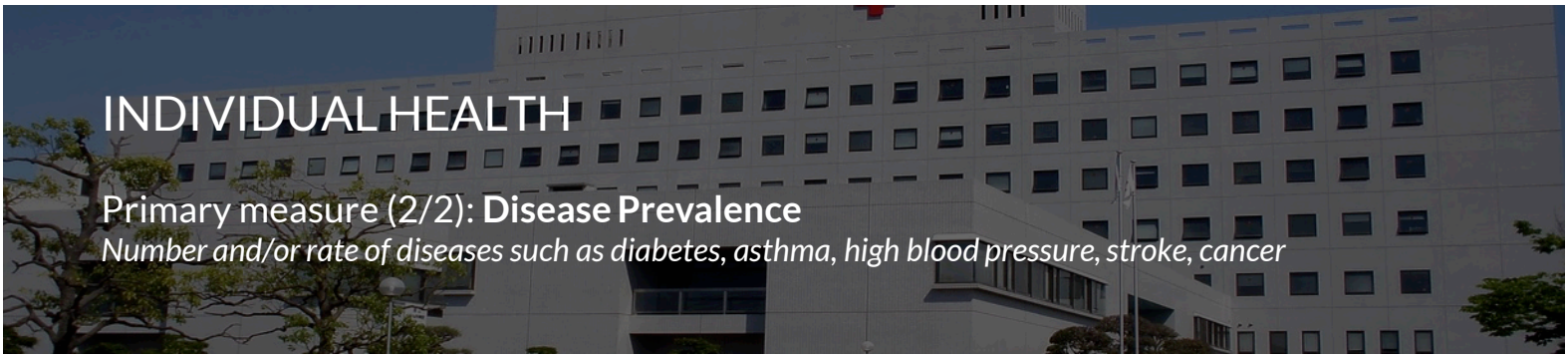


Alternative measures

Regions can also utilize health surveillance surveys and health models to calculate a **healthy body mass index (BMI)** measure. One benefit of this measure is that it is easier to calculate and track in comparison to other health measures. It is acknowledged that BMI can be impacted by many factors other than physical activity, including diet and genetics.

Measure	Tier	Project Evaluation	Scenario Analysis	Performance Monitoring	Goal Direction	Data Requirements
Healthy Body Mass Index	Opportunities		✓	✓	Minimize number of persons with above average BMI	• National (BRFSS) or state/local health surveillance surveys (current conditions) • Health models, such as those developed by Urban Design 4 Health, based on demographics, built environment, natural environment, and residence location (for forecasted conditions)

[22] Nashville MPO. (2015). 2014 Regional Bicycle & Pedestrian Non-Motorized Demand Physical Activity Assessment. http://www.nashvillempo.org/docs/bikeped/Non-MotorizedDemand_TechMemoDraft012715.pdf



INDIVIDUAL HEALTH

Primary measure (2/2): **Disease Prevalence**

Number and/or rate of diseases such as diabetes, asthma, high blood pressure, stroke, cancer

Why it's important

There is a strong linkage between non-motorized transportation options, physical activity, and disease prevalence. The public costs of treating chronic conditions can be substantial, providing even more incentive for regions to prioritize strategies to reduce disease prevalence through increased physical activity.

General methodology

Using national data, namely the Center for Disease Control's Behavioral Risk Factor Surveillance System Survey (BRFSS), or state health surveillance surveys, determine existing levels of disease prevalence including diabetes, asthma, high blood pressure, stroke, and cancer. Sophisticated modeling techniques linking disease prevalence to built environment variables also allow regions to model disease prevalence based on changes to land use and transportation.

Putting it into practice

Some regions have begun modeling this through land use and transportation scenario planning tools informed by health research, such as that conducted by Urban Design 4 Health in California and elsewhere. For those that lack the data and modeling capacity, monitoring changes through survey data over time and comparing to transportation and land use investments is a useful starting point. Once disease prevalence is known for current conditions, and either tracked over time or estimated for future scenarios, the costs saved through avoided disease prevalence is an excellent calculation for showing the return on investment and economic benefits for a given set of investments and policies.

- **Nashville Area MPO:** To date, modeling capacity has been a key challenge to regions assessing disease prevalence as part of the project evaluation process. The Nashville Area MPO addressed disease prevalence in their project evaluation process by prioritizing projects with transit, bicycle, or pedestrian components that serve census tracts in the region with higher than average rates of demographic characteristics found to be highly correlated with a likelihood of chronic disease prevalence. This was done using the results of their health survey and the Integrated Transport and Health Impact Modeling Tool (ITHIM). ITHIM uses relative risks and burden of disease to estimate avoided illnesses (as measured by disability adjusted life years) and deaths for nine conditions identified in BRFSS.

- **SCAG & Metro:** As an example of scenario analysis, in their current Draft 2016 RTP/SCS, SCAG uses statistical models based on the results of a local health survey to estimate the changes in levels of obesity, heart disease, hypertension, Type 2 Diabetes, and minutes of active travel per day. They also monetized the regional impact of the changes in obesity and prevalence of chronic diseases to derive the annual estimated benefit to the region of the plan in the form of reduced healthcare costs. [23] Metro partnered with the Oregon Health Authority (OHA) to conduct a series of three health impact assessments (HIAs) on regional-level scenarios to ensure that decision-makers had access to public health evidence and best practices as they shaped and approved a greenhouse gas reduction strategy for light duty vehicles. Using ITHIM, OHA compared the scenarios' health benefits and costs associated with traffic safety, air quality and physical activity. Data from the regional travel demand model and a GHG emissions analysis tool called GreenSTEP (developed by the Oregon Department of Transportation), were used for future year estimates of travel and emissions. OHA also monetized the healthcare cost savings from reduced illness and value to society of lives saved to demonstrate the significant economic benefits of improved health outcomes.[24] (See the last graphic on the following page, which illustrates OHA's process.)

[23] SCAG. (2016). Draft 2016 RTP/SCS: Chapter 8: Measuring Our Progress for the Future.

[24] More information about this work can be found at www.oregonmetro.gov/climate-smart-strategy and https://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Pages/CSCHIA.aspx

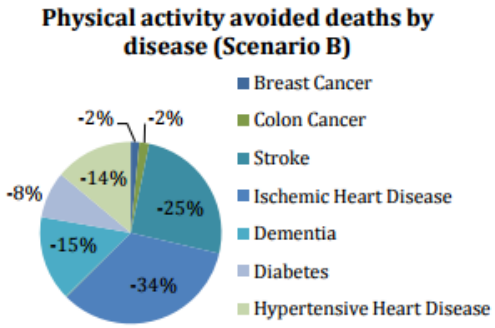
Examples

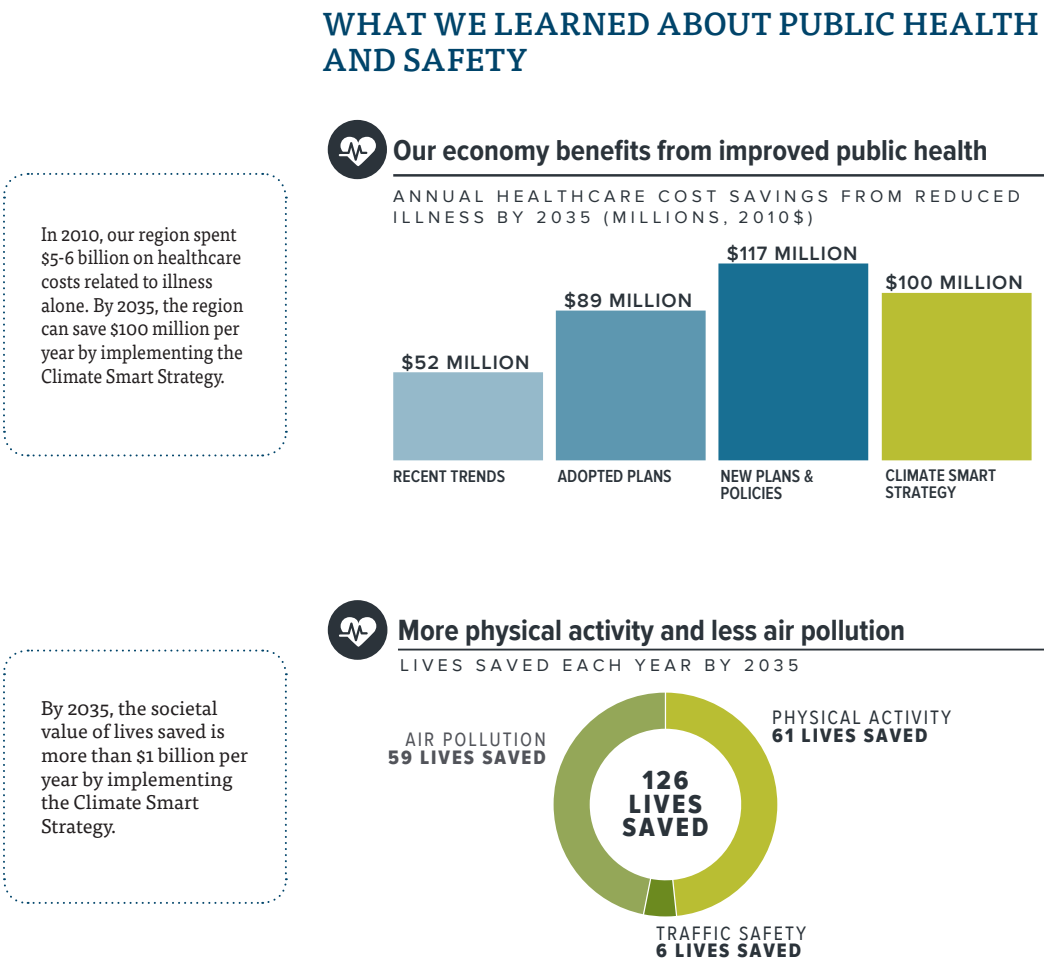
ITHIM results from Metro's 2014 Climate Smart Communities Scenarios Report demonstrated estimates for avoided illnesses and deaths as a result of improved traffic safety, air quality, and physical activity in their regional plan scenario.[25]

Table 7. ITHIM results attributable to physical activity

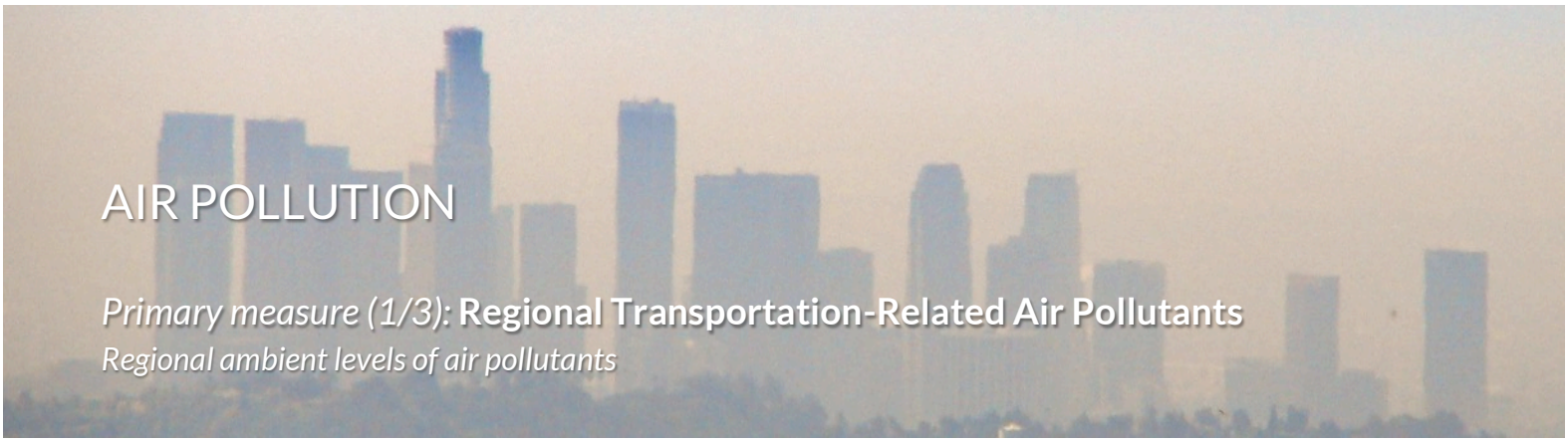
Avoided	Scenario A		Scenario B		Scenario C	
	Count[1]	Percent	Count[1]	Percent	Count[1]	Percent
Mortality	-58	1.4%	-89	2.1%	-116	2.9%
YLL	-468	1.5%	-747	2.3%	-988	3.1%
YLD	-325	1.0%	-586	1.6%	-799	2.3%
DALY[2]	-793	1.3%	-1333	1.9%	-1786	2.8%

(1) This count has been adjusted for expected population in 2035.
(2) Disability adjusted life years (DALY) is the summation of years of life lost (YLL) and years living with a disability (YLD) due to injury or disease. Note that YLD assumptions were not available for some sub-categories and therefore significantly underestimate DALYs for physical activity and air quality.





[25] Oregon Health Authority. (2014). Climate Smart Scenarios HIA. https://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/CSCS/FINAL_Climate%20Smart%20Communities%20Scenarios.pdf



AIR POLLUTION

Primary measure (1/3): **Regional Transportation-Related Air Pollutants**

Regional ambient levels of air pollutants

Why it's important

Fine particulate matter (PM) air pollutants (denoted by size, with the PM2.5 category including particulate matter under 2.5 microns) are a key public health hazard, and transportation plays a key role in reducing PM2.5 levels. Exposure to air pollution increases the rate of health problems, including respiratory conditions, cardiovascular disease, and Type II diabetes, among others. Establishing a transportation-related air pollutant performance measure for the entire region helps assess progress in reducing pollution.

General methodology

Each region will have its own methods for measuring air pollution based on conformity requirements. A general methodology is to use state environmental agency National Ambient Air Quality Standards (NAAQS) data to calculate, for PM, the annual average ($\mu g/m^3$), number of days/year where 24-hour levels are less than 12 $\mu g/m^3$, number of days/year where 36-hour levels are less than 12 $\mu g/m^3$, and, for ozone, the number of days/year out of attainment (8-hour>0.075ppm).

Data and technical requirements:

- State environmental agency NAAQS tracking data

Evaluation level:

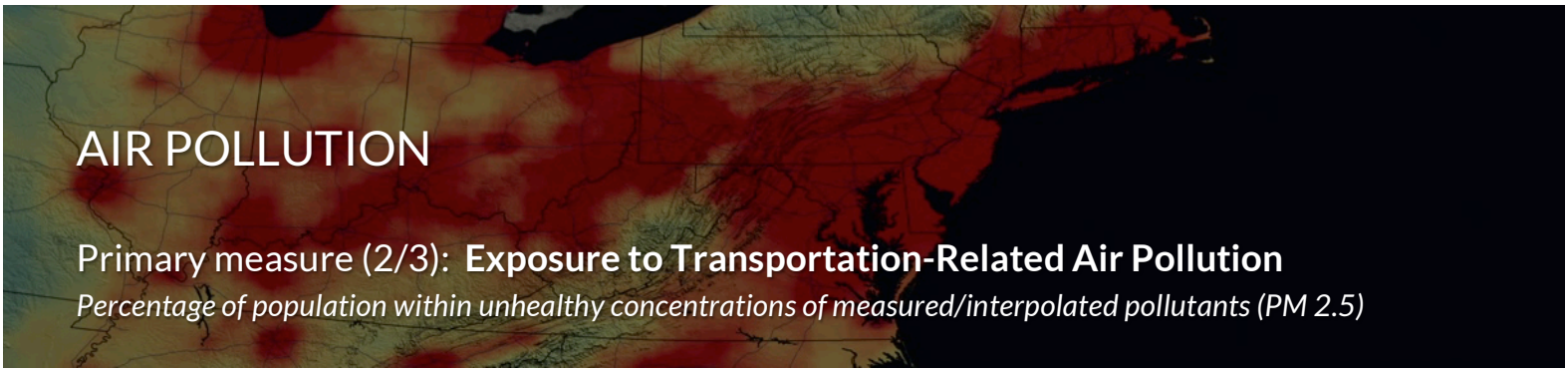
Project Evaluation	✓
Scenario Analysis	✓
Performance Monitoring	✓

Putting it into practice

Many states provide specific guidance on evaluating air pollutants, including acceptable thresholds, key data sources, and other resources. Regions can look for opportunities to gather localized rather than regional air pollutant levels, which enables more focused evaluation of impacts on various demographic groups.

Current usage

While all of the regions collaborating on this report monitor air pollution levels in some aspect, the manner in which they measure pollution levels and exposure to air pollution differs. **Metro, PSRC and Nashville Area MPO** conducted their own regional analyses of PM2.5 as part of the RTP process and required conformity analysis. Additionally, Metro reports air toxics emissions per an agreement with the Oregon Department of Environmental Quality as part of the conformity process. In San Diego, the local Air Pollution Control District monitors and evaluates most pollutants, including PM2.5. Given this, **SANDAG** instead focuses its efforts on ozone and carbon monoxide. Additionally, SANDAG incorporated an exposure to air pollution measure as part of their regional scenario analysis.



AIR POLLUTION

Primary measure (2/3): **Exposure to Transportation-Related Air Pollution**

Percentage of population within unhealthy concentrations of measured/interpolated pollutants (PM 2.5)

Why it's important

Fine particulate matter (PM) air pollutants are a key public health hazard, and exposure to air pollutants often disproportionately affect low-income and other traditionally marginalized communities who live near major polluting source.[26] Exposure to air pollution increases the rate of health problems including respiratory conditions, cardiovascular disease, and Type 2 diabetes, among other illnesses. Certain age groups (seniors and youth) are also particularly sensitive to exposure to air pollution. Establishing a transportation-related air pollutant performance measure based on exposure for target populations helps regions measure and improve the environmental health for all of its residents.

General methodology

Using point- and mobile-source air pollution data and census data, calculate the percent of the population living, working, and attending school in areas that have annual average air pollution levels ($\mu g/m^3$) that are higher than unhealthy concentrations of measured/ interpolated pollutants (PM2.5) as defined by regulations and research. If mobile-based pollution data are not available, proxies can be developed with local experts to identify likely major sources of pollution.

Data and technical requirements:

- Major pollution sources (either proxies or through air quality monitors and models)
- Household, work and school locations

Evaluation level:

Project Evaluation	✓
Scenario Analysis	✓
Performance Monitoring	✓

Putting it into practice

In most regions, air pollution exposure analyses are incorporated into their transportation conformity program. State environmental agencies often have monitoring data for pollution by point, area, and mobile sources. While point-sourced data is commonly available, the difficulty of collecting localized mobile source pollution presents a challenge.

Another challenge is that while PM 2.5 is very harmful, the primary source of this pollutant is heavy trucks, not passenger vehicles. Heavy trucks also produce NO_x and SO_x, which are less toxic than PM2.5 and are best reduced with new trucks. A filter is best used to reduce PM2.5 emissions such as an ammonia system or a diesel particulate filter. Other pollutants such as air toxins, which are not currently regulated, are more prevalent to passenger vehicles. Additionally, while some states have policies to control PM2.5 with a Vehicle Inspection/Maintenance Program (I/M Program), this framework applies only to passenger vehicles; PM2.5 emissions associated with freight trucks are not regulated.

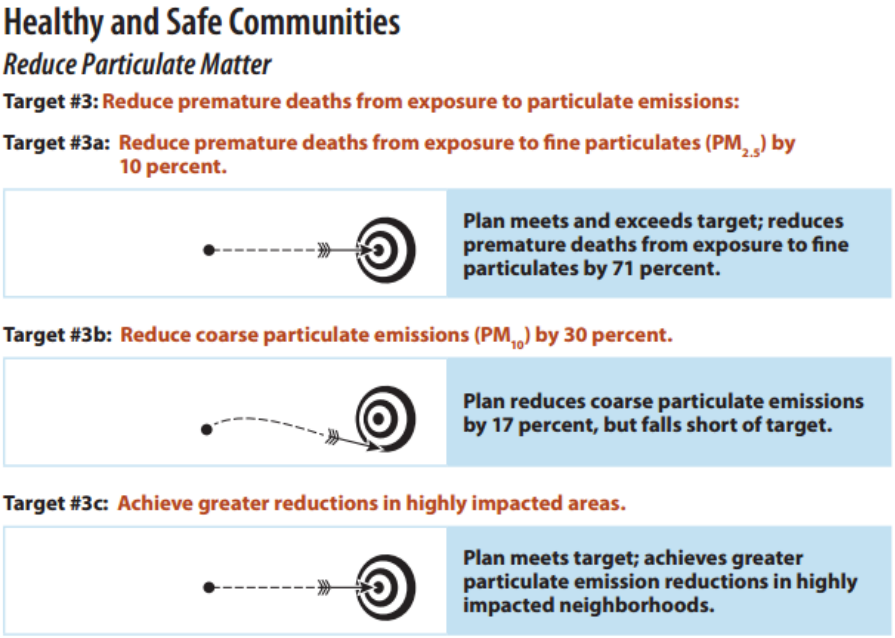
As a standalone, this measure could discourage land use strategies that seek to increase development densities, especially in areas near major roads (which can be related to higher levels of air pollution). Because of this, regions should assess this measure alongside infill development or transit oriented development (TOD) goals to illuminate scenarios that do not sacrifice one objective for the other. Regions should also take into consideration smaller scale land use and urban design strategies that are known to mitigate air pollutants such as building design, tree planting, and street design. While none of these approaches are perfect solutions to the issue, they can help ensure that adopted land use strategies have the lowest possible impact on residents.

[26] Miranda ML, Edwards SE, Keating MH, Paul CJ. (2011). Making the environmental justice grade: the relative burden of air pollution exposure in the United States. Int J Environ Res Public Health 8:1755–1771. And:
Bell, Michelle; & Ebisu, Keita. (2012). Environmental Inequality in Exposures to Airborne Particulate Matter Components in the United States. Environmental Health Perspectives. Volume 120. Issue 12.

- **SANDAG & MTC:** As an example of scenario analysis, SANDAG measured exposure to PM10 as part of their regional analysis, including the social equity section of the RTP. Average exposure for low-income, minority, and senior populations compared to the rest of the region was assessed. MTC incorporated a series of performance measures related to exposure to air pollutants in their 2013 Plan Bay Area. They also set a target for each measure to assess scenario performance and the final outcome. These targets were to reduce premature deaths from exposure to PM2.5 by 10 percent, to reduce PM10 by 30 percent, and to ensure that neighborhoods that currently have the highest pollution concentrations achieve the greatest emission reductions. They also report annual average and worst location PM2.5 concentrations via their public data portal, Vital Signs.

Example

MTC's Plan Bay Area Performance includes targets related to exposure to particulate emissions in the Bay Area. [27]



[27] Metropolitan Transportation Commission. (2013). Plan Bay Area. Chapter 5: Performance. http://planbayarea.org/pdf/Draft_Plan_Bay_Area/05-Performance.pdf

AIR POLLUTION

Primary measure (3/3): **Transportation-Related Greenhouse Gas Emissions**

GHG (CO_2 equivalent) associated with passenger vehicles

Why it's important

Greenhouse gas (GHG) emissions are the most direct measure for quantifying efforts to mitigate climate change. Transportation emission levels vary significantly according to the transportation modes targeted for investment and the land use patterns the investments facilitate. Comprehensively modeling the GHG emissions of regional plans puts the role of land use and transportation decisions in context with carbon reduction policies and strategies across sectors. A more comprehensive accounting at the regional level would include emissions associated with building energy and water use.

General methodology

GHG emissions for the transportation sector are calculated on the basis of modeled vehicle miles travelled based on land use patterns, vehicle fleet performance assumptions, and projected emission rates for vehicle fuels and energy sources.

Data and technical requirements:

- Land use patterns
- Total vehicle miles traveled
- Vehicle fleet performance assumptions
- Emission rate assumptions for vehicle fuels and energy sources

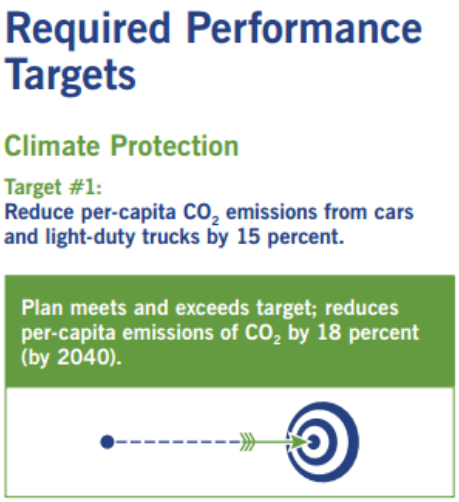
Evaluation level:

Project Evaluation	✓
Scenario Analysis	✓
Performance Monitoring	✓

Putting it into practice

Greenhouse gas (GHG) emissions associated with the transportation sector is an environmental measure that is widely used by the four MPOs that collaborated on this report.

- **SANDAG and PSRC:** Both analyze transportation-related GHG emissions both for project evaluation and regional analysis.
- **Metro**: Metro measures transportation-related GHG emissions for its regional analysis.
- **Nashville Area MPO**: While it does not directly measure GHG emissions for regional analysis in its RTP process, the Nashville Area MPO access to a GHG assessment conducted for the most populated subarea of the region, Davidson County.
- **MTC**: Reducing CO_2 emissions from cars and light-duty trucks is one of the Bay Area MPO's primary performance measures. Ultimately, their plan exceeds the target they initially set, projecting a reduction of 18 percent by 2040.[28]



[28] MTC (2013). Plan Bay Area. Chapter 5: Performance.

Additional measures

Calculating the GHG emissions attributable to different sectors beyond transportation, including those from building energy and those related to the transportation, treatment, and distribution of water, is useful as it surfaces the impacts that different transportation and land use combinations have on the region-wide totals. Calculating GHG emissions associated with building energy and water use requires first modeling land use scenarios and their associated building programs, and subsequently applying emission rate assumptions by energy source.

Measure	Tier	Project Evaluation	Scenario Analysis	Performance Monitoring	Goal Direction	Data Requirements
Building GHG Emissions	Outcomes		✓	✓	Minimize overall GHG emission levels	• Floor area by building type • Energy use intensity assumptions • GHG emission rates
Water Energy GHG Emissions	Outcomes		✓	✓	Minimize overall GHG emission levels	• Water use • Water-energy use assumptions • GHG emission rates