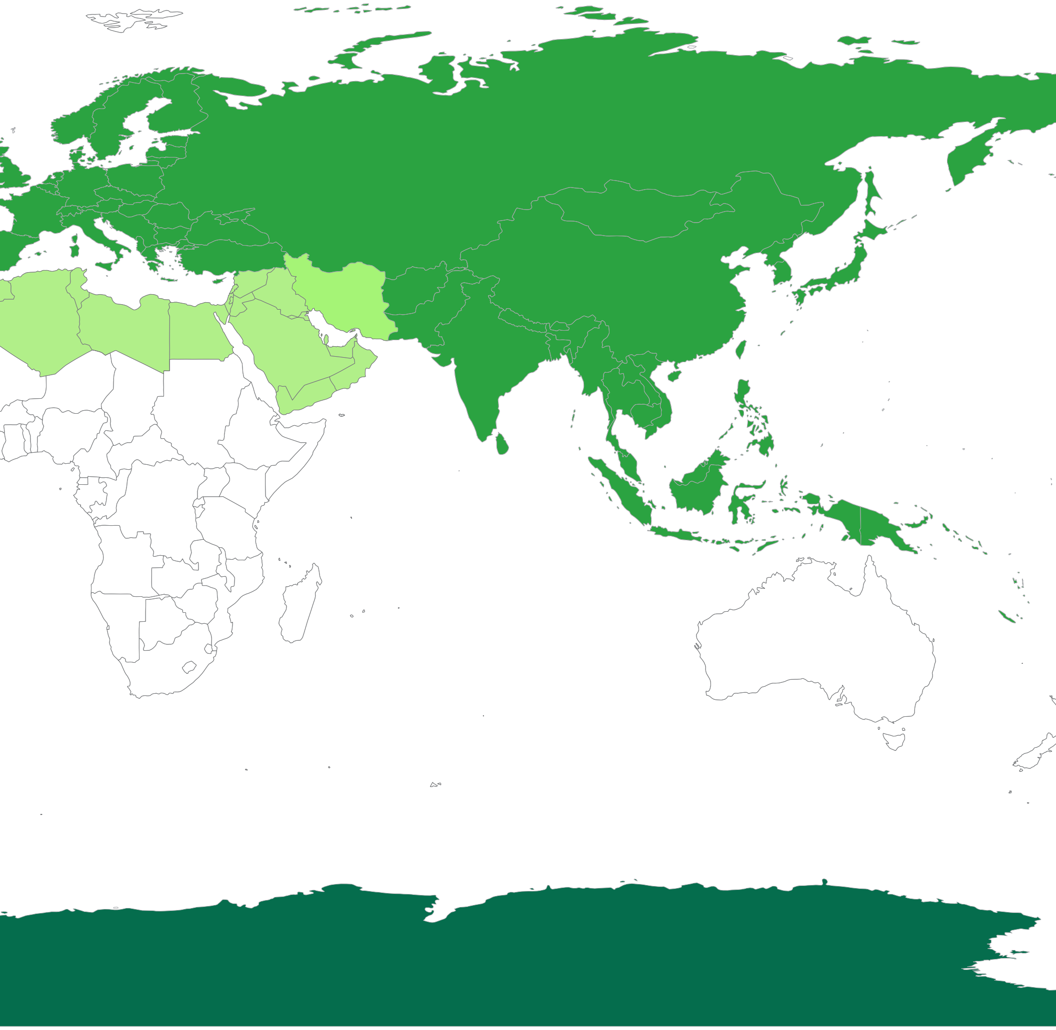
SUSTAINABLE TRANSPORTATION

AN INTERNATIONAL PERSPECTIVE



PROJECTIONS *volume 9* MIT JOURNAL OF PLANNING

A NOTE OF THANKS Editorship is an adventurous journey. I learned a lot and enjoyed it – and it could not have been possible without my mentors and supporters. First, I would like to thank Larry Vale, my faculty advisor, for his support, his guidance and practical advice throughout the process of bringing this *Projections* volume to life. I am also grateful to Ezra Glenn for pushing forward this volume and the journal's future.

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The former managing editors of Projections were very open in sharing advice - thank you Anna Brand, Isabelle Anguelovski and Rachel Healy. I hope you will enjoy the layout of this volume, and would like to thank Marissa for designing and improving the graphic design with her ideas. - EVA KASSENS, 2009

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COVER IMAGE Map courtesy of Eva Kassens; data courtesy of World Resources Institute, 2005. This map shows CO_2 emissions by transport as a percentage of emissions. The more grey the continent, the higher the CO_2 transport emissions in relation to total emission of that continent; the more greeen the continent, the lower the CO_2 transport emissions in relation to total emission of that continent.

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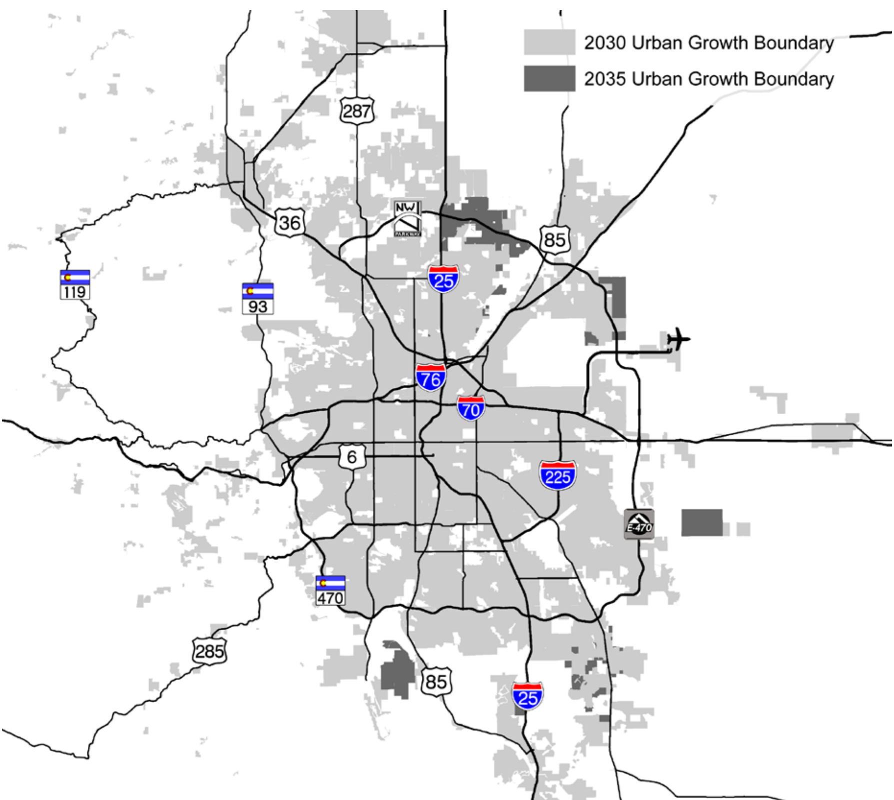
SCENARIO ANALYSIS HELPS IDENTIFY SUSTAINABLE LAND USE AND TRANSPORTATION POLICIES



ABSTRACT

The Denver Regional Council of Governments (DRCOG) recently updated Metro Vision, the region's long-range plan for growth, transportation and the environment. As part of the update process, DRCOG explored future scenarios reflecting different land use and transportation policies. On the land use side, scenarios ranged from compact to expansive development patterns. On the transportation side, scenarios ranged from an emphasis on roadway improvements to an emphasis on transit improvements. Scenarios that favored compact development patterns and transit investments performed best on a variety of outcome measures including transportation system performance, infrastructure costs, accessibility and environmental impacts. In contrast, scenarios that significantly expanded the region's urban "footprint" did not perform as well and resulted in greater overload of key regional transportation facilities. The results of the scenario analysis influenced the DRCOG Board's deliberations regarding how much to expand the region's urban growth boundary to accommodate additional growth between 2030 (the previous planning horizon) and 2035. Before the scenario analysis, the Board was considering expanding the boundary by 70 square miles; after the analysis the Board decided to expand the boundary only 21.8 square miles. The adopted 2035 urban growth boundary represents an ambitious effort to curb current trends toward expansive development, and will require a significant increase in overall density in the Denver region.

Scenario Analysis Helps Identify Sustainable Land Use and Transportation Policies

Metropolitan areas across the country stand at an important transition point as development patterns that prevailed for the past half century come under intense public scrutiny. Congestion, pollution, competition for water, infrastructure funding shortfalls, global economic trends and concerns about energy sustainability and climate change all come together with unprecedented demographic changes resulting from the aging of the baby boomer generation (see for example Ewing, Bartholomew, Winkleman, Walters and Chen, 2007; Nelson, 2006; Puentes, 2008; Regional Plan Association, 2006; Richie, 2001; ULI-The Urban Land Institute and Ernst & Young, 2008). The metropolis as we know it is changing.

Cognizant of these forces, the Denver Regional Council of Governments (DRCOG) conducted a comprehensive scenario analysis as part of the recent update to Metro Vision, the region's long-range plan for growth and development (Denver Regional Council of Governments, 2007). Since its initial adoption in 1997, Metro Vision has promoted sustainable growth through policies such as an urban growth boundary (UGB), support for higher-density, mixed-use urban centers and the development of a balanced, multi-modal transportation system.

Scenario analyses are used widely in the private sector to prepare for future contingencies beyond organizational control (Smith, 2007). By contrast, the public sector typically uses scenarios to decide how best to influence the future, incorporating stakeholder input and values (Avin, 2007). Over the past 20 years, land use-transportation scenario analyses have become increasingly common in regional planning and often explore the potential benefits of increased density. A recent review of 80 scenario analyses from more than 50 U.S. metropolitan areas (Bartholomew, 2007) found that a median density increase of 11% was associated with median decreases of 2.3% in vehicle miles traveled (VMT) and 2.1% in NOx emissions. Similarly, a study of alternative development futures for 11 major metropolitan areas in the Midwestern U.S. concluded that a 10% increase in density would result in a 3.5% reduction in VMT and associated emissions (Stone, Mednick, Holloway & Spack, 2007). Bartholomew (2007) criticizes many of these previous efforts, however, for being disconnected from the planning process and not leading to concrete action or implementation steps.

DRCOG's scenario analysis, in contrast, was directly connected with the Metro Vision planning process and focused on the agency's two main areas of influence: the allocation of transportation funds and the extent of urban development (Figure 1). On the transportation side, scenarios ranged from an emphasis on roadway improvements to an emphasis on transit improvements. On the land use side, scenarios ranged between compact and expansive development patterns. All scenarios included the build-out of FasTracks, the taxpayer-funded plan to build 120 new miles of rapid transit throughout the Denver region by 2016 (Regional Transportation District, 2004). DRCOG developed the scenarios by starting with the then-current Metro Vision 2030

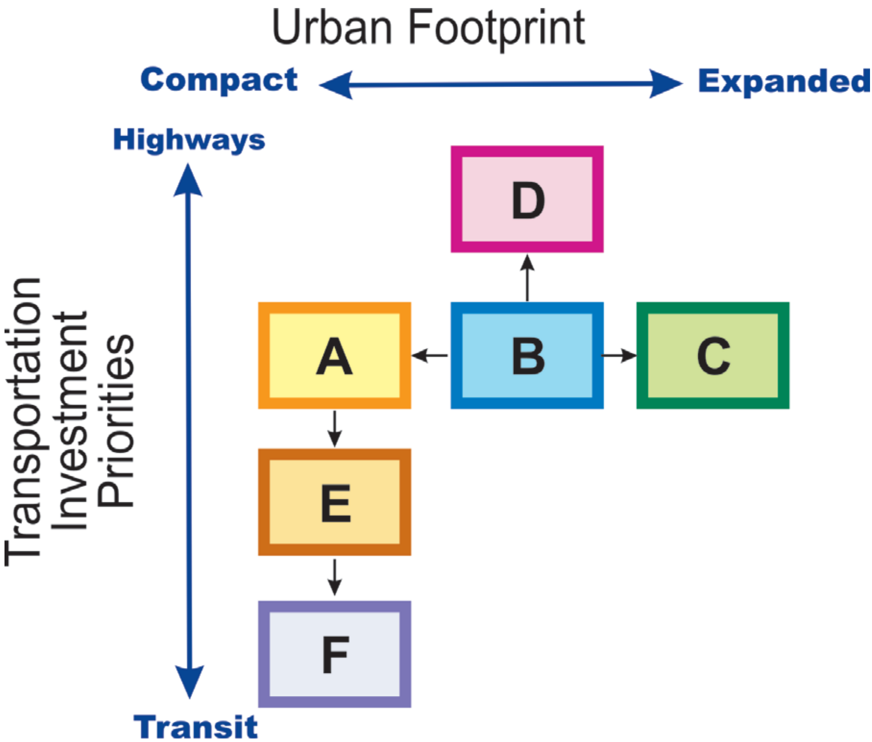


FIGURE 1. Distribution of the scenarios across policy space.

plan, extending the horizon to 2035 and examining changes to the UGB, fiscally constrained roadway and transit networks, and pricing of driving versus taking transit. Table 1 describes the specific parameters associated with each scenario.

Scenario Outcomes

We evaluated the performance of each scenario on 12 outcome measures reflecting conditions in 2035 (Table 2). The measures relate to Metro Vision policy goals, and are broadly grouped into land use, transportation, and environment. DRCOG's land use model (Denver Regional Council of Governments, 2008) produced the land use measures. The model allocates jobs and households to transportation analysis zones based on each zone's utility (attractiveness) and capacity to accommodate growth. Zone utilities and capacities were adjusted to reflect each scenario's land use assumptions. We then used output from the land use model to calculate cost- and water-related measures based on the assumptions in Table 3, derived from previous research (Denver Regional Council of Governments, 2006; Guimond & Arbogast, 1995; Mullen, 2005; Nelson 2004).

TABLE 1. Scenario Descriptions

Scenario	Expansion of 2030 UGB	Density increase (2000-2035)[a]	Change to 2030 fiscally constrained roadway network	Change to 2030 fiscally constrained transit network	Pricing changes
A	None	23%	None	None	None
B	+ 70 square miles	12%[b]	+ 300 miles of minor arterials and collectors[c]	None	None
C	+ 150 square miles	0%	+ 600 miles of minor arterials and collectors[c]	None	None
D	+ 70 square miles	12%	+300 miles of minor arterials and collectors[c]; + 300 miles new freeway/tollway capacity[d]	None	None
E	None	23%	- 100 miles of highway capacity[e]	Additional rail and bus rapid transit[f]	None
F	None	23%	- 100 miles of highway capacity[e]	Additional rail and bus rapid transit[f]	Auto operating costs doubled; transit free

[a] Assumes the number of households within the UGB increases from 869,000 in 2000 to 1,654,000 in 2035.

[b] Based on the Metro Vision goal of increasing density 10% between 2000 and 2030. Extended out to 2035, this results in a density increase of 12% compared to 2000.

[c] New facilities serving the expanded UGB area.

[d] Estimated cost of $8 billion.

[e] Estimated cost savings of $1.5 billion.

[f] Estimated cost of $2.5 billion.

TABLE 2. Performance of Scenarios on Outcome Measures Reflecting 2035 Conditions						
Measure (units) *"Better" outcome*	Scenario					
	A	B	C	D	E	F
Land use						
Additional land developed compared to 2030 (sq. miles) *Less land consumption*	0	70	150	70	0	0
Public infrastructure costs[a] ($ billions) *Less spending on infrastructure*	14.2	16.5	19.3	16.5	14.2	14.2
Households and jobs within 1/2 mi. of high-capacity transit (thousands) *More development around transit*	HH 151 Emp 619	HH 145 Emp 602	HH 138 Emp 584	HH 139 Emp 585	HH 198 Emp 728	HH 198 Emp 728
Population and employment in urban centers (%) *More development in urban centers*	Pop 23 Emp 47	Pop 20 Emp 44	Pop 19 Emp 42	Pop 19 Emp 43	Pop 23 Emp 47	Pop 23 Emp 47
Population and employment in Denver CBD (%) *More development downtown*	Pop 1.6 Emp 8.6	Pop 1.3 Emp 8.4	Pop 1.1 Emp 8.1	Pop 1.3 Emp 8.4	Pop 1.6 Emp 8.6	Pop 1.6 Emp 8.6
Transportation						
Vehicle miles traveled (millions) *Less driving*	117.3	121.6	125.1	124.6	116.5	114.0
Vehicle hours of delay (millions) *Less congestion*	1.17	1.21	1.35	1.15	1.16	1.10
Transit trips (thousands) *More transit use*	494	465	447	420	501	613
Low income/minority access to employment by transit (% zones $<$45 min. to 100,000 jobs) *Better access to transit*	50	48	45	48	52	53
Environment						
Air pollutant emissions[b] (tons/day) *Cleaner air*	1,289	1,347	1,373	1,365	1,282	1,246
Water demand (billions of gallons/year) *More efficient water use*	208	313	315	313	308	308
New wastewater treatment service needed (millions of gallons/day) *Less need for new service*	29	45	56	45	29	29

[a] Excludes regional transportation and wastewater treatment facilities

[b] Includes Carbon Monoxide, NOx, VOC and PM_{10}

TABLE 3. Assumed Relationship between Land Use, Public Infrastructure Costs, Water Demand and Wastewater Flows

	Public infrastructure costs[a]		Water demand[b]	Wastewater flows[c]
	Greenfield (2005 $/acre)	Infill (2005 $/acre)	(Gallons per year per household or employee)	(Gallons per day per person or employee)
Residential, 1 to 12 dwelling units/acre	$82,600	$66,080	144,880	85
Residential, 12 dwelling units/acre or greater	$140,420	$112,336	67,440	85
Retail	$90,860	$72,688	18,300	50
Office	$107,380	$85,904	18,300	50
Industry	$41,300	$33,040	18,300	50

[a] Net cost for new development only. Excludes regional facilities, such as new principle arterials or new wastewater treatment plants.
[b] Demand for municipal water supplies only; excludes self-supplied industrial.
[c] Calculated for new development located outside existing wastewater treatment facility service areas. Excludes industrial flows treated on-site.

The land use model also provided input to DRCOG's four-step travel demand model (Denver Regional Council of Governments, 2005), which produced the transportation measures. The model's roadway and transit networks, as well as user costs for each mode, were modified to reflect the transportation assumptions of each scenario. The travel model in turn provided input to the latest EPA air pollution emission model, MOBILE6 (U.S. Environmental Protection Agency, 2008), which produced the air quality measure.

Figures 2 through 4 graphically compare the scenario outcomes. These figures display each outcome measured along one of the "spokes" of the diagram.[1] Results covering a larger area of the diagram reflect better (more desirable) outcomes. Figure 2 compares the scenarios that varied along the land use dimension, and shows that the most compact scenario (A) produced the best outcomes. Figure 3 shows that the additional highway capacity in Scenario D resulted in less congestion, but also more driving, less transit use, and greater pollution than Scenario B. Figure 4 shows that the additional transit capacity in Scenario E resulted in only marginally better outcomes compared to Scenario A. This result suggests that FasTracks will go a long way toward meeting the region's transit needs, with only minimal benefit derived from the additional

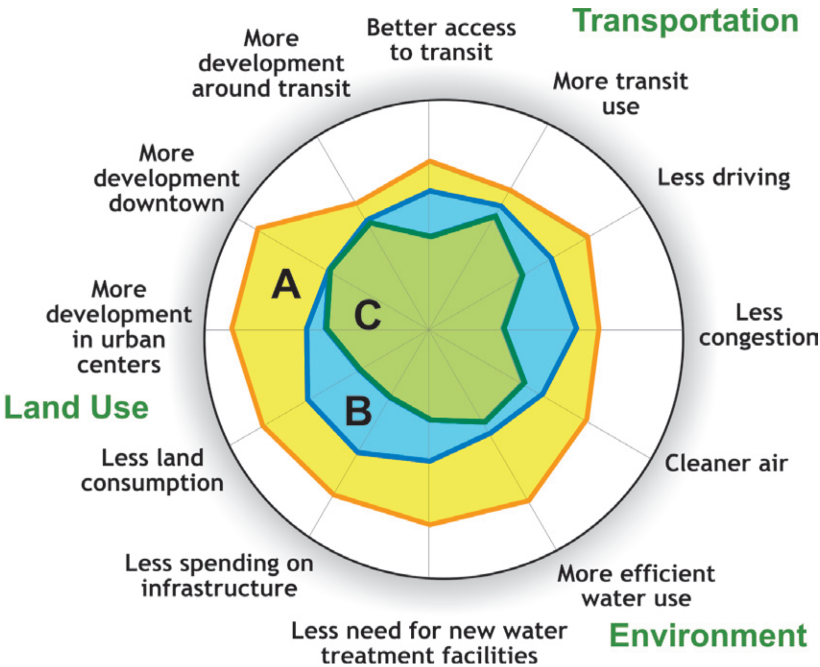


FIGURE 2. Outcomes of Scenarios A, B and C.

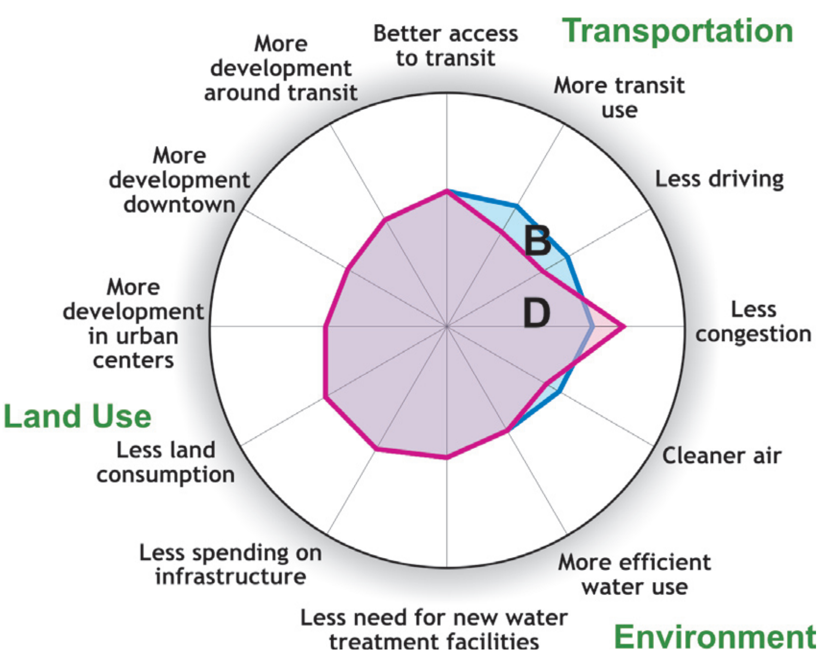


FIGURE 3. Outcomes of Scenarios B and D.

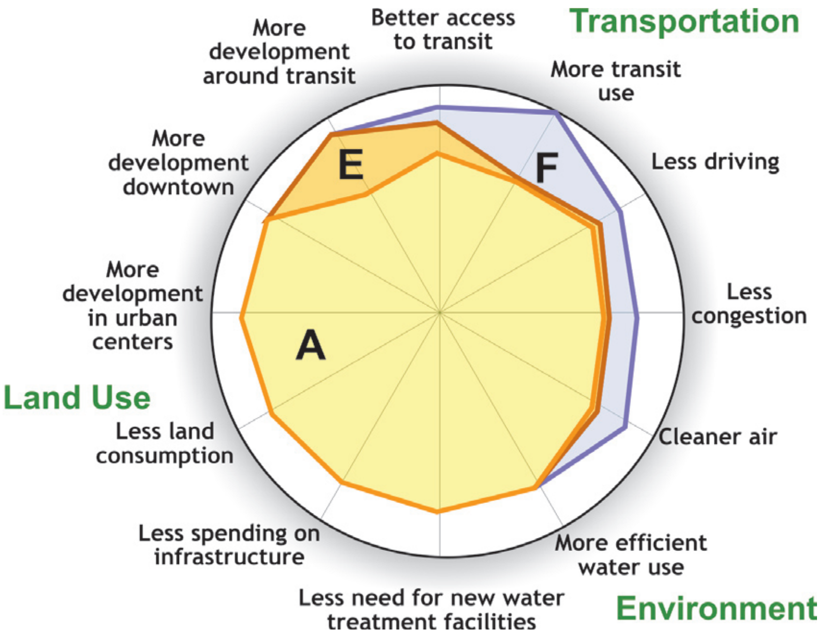


FIGURE 4. Outcomes of Scenarios A, E and F.

transit improvements examined. Figure 4 also shows, however, that the inclusion of transit-favorable pricing in Scenario F resulted in a more dramatic shift toward desirable outcomes. In fact, Scenario F performed best of all the scenarios in the analysis. This result indicates that travel behavior is sensitive to pricing and that transit-favorable pricing can result in increased transit use and the related benefits of less congestion and pollution.

Limitations

Many of the assumptions underlying the outcome measures are based on observations of past trends and behavior. It is uncertain how valid these assumptions are when considering unprecedented changes, such as the dramatic shift the in cost of driving versus taking transit in Scenario F. Furthermore, traditional four-step travel demand models like DRCOG's deal only indirectly with non-motorized trips and do not capture the effect of fine-grained land use patterns such as mix of use and walkability (Cervero, 2006). Our analysis may therefore have underestimated the impact of compact development patterns and transit investments on the use of alternative modes and the related benefits for regional sustainability. DRCOG is currently developing a disaggregate activity-based model that will address some of these shortcomings (Sabina and Rossi, 2008).

Conclusions

DRCOG's scenario analysis is consistent with other analyses indicating the benefits of compact development. This provided the DRCOG Board of Directors with meaningful, actionable information for their regional decision-making. Before staff conducted the scenario analysis, the Board was considering expanding the UGB 70 square miles, as in Scenario B, to accommodate growth between 2030 and 2035. After reviewing the results of the analysis, the Board decided to expand the UGB a modest 21.8 square miles and to make only minor updates to the 2030 transportation network. The adopted 2035 urban growth boundary represents an ambitious effort to curb current trends toward expansive development, and will require a significant increase in overall density. DRCOG's experience demonstrates the tangible benefit of scenario analyses in exploring policy alternatives and identifying the optimal transportation investment and land use strategies for achieving regional sustainability goals.

AUTHORS' BIOGRAPHIES

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ENDNOTES

[1] In order to present the outcomes in this format, each parameter was normalized using a z-score statistic.

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